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THE STRUCTURE OF THE SIDEREAL UNIVERSE.

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FOR THE MESSENGER.

This is a subject which until lately does not seem to have received much attention since the late R. A. Proctor's "The Universe" appeared. Dr. B. A. Gould, in the "Uranometria, Argentina," has made some investigations into the form of the stellar universe, his results not being altogether in accordance with Proctor's; it is encouraging to see that others are now taking the subject up, though it does not appear that they have examined much into *details* of structure until within the last few months. The small amount of attention paid to the subject cannot arise from any lack of inherent interest it possesses, for it is one of the most important and mysterious in the whole range of astronomy; but it may be from an idea that observational astronomy would be unremunerative in this direction. But is this likely to be the case? Any theories that may be formed must be based on the knowledge of facts; and in one department of the subject in particular, namely, stellar distribution, Proctor has pointed out that much can be done towards increasing that knowledge. The application of photography to the stars, and further observations of their motions in the line of sight and across it, will accumulate much material for the confirmation or refutation of existent theories; but the present paper is written specially with a view of pointing out a few facts which have been gleaned by direct observation of one particular area of the sky. Any theory that may be advanced will have to account for these and similar facts that may be corroborated or accumulated by other observers. More persons are likely to pursue investigations of this kind when they realize that they will thereby be brought into acquaintance with scenes than which none are

more glorious, nor do any in the whole range of nature show the greatness of God more. And our admiration of His marvellous handiwork must be increased, even should the result be to diminish our ideas of the extent of the visible universe; and the substitution of facts for fancies can only be gain.

One of the most striking of the unexplained features of the structure of the universe is the *parallel arrangement;* sometimes simply of pairs of stars, at others of longer lines, or of broader bands of numerous stars, or of irresolvable nebulous wisps. This parallelism gives one the impression that the stars and wisps so arranged are physically connected, and the reality of this impression is a fair subject of enquiry. A very conspicuous instance of parallelism visible to the naked eye is in the region of the sky from Castor to ξ Ursæ Majoris, where we have the ten brightest stars arranged in five pairs, of which three are approximately parallel, and the other two do not deviate greatly from their direction, viz., Castor and Pollux, 38 and α Lyicis, ι and $\varkappa$ Ursæ Majoris λ and μ, and ν and ξ. This parallelism may even be traced, though less distinctly, over a much wider extent, including γ and δ Cancri, ζ and γ Leonis, η and α, δ and θ, ι and σ, 93 and β. But if we look at Proctor's map of the proper motions of the stars in "The Universe" (at end of volume) we find that there is no common proper motion among these stars, nor even in the two stars of each pair; the idea of physical connection seems therefore negatived, for if the two stars of the pairs are moving in different directions, whether one be revolving round the other or not, it is clear that in time the parallelism will be destroyed, unless the motion in all the pairs is similar—which is not the case. Nevertheless the conclusion is irresistible that in many cases such arrangement must be indicative of actual association.

For examination into details of structure the portion of the Milky Way between α Orionis and μ Geminorum was selected, and observed for the configurations of the stars, wisps, etc., contained in it, partly with a 4¼-inch refractor, but chiefly with a binocular field-glass of 2.05 inches aperture and power about 3.8; nearly all the observations having been made at Sunderland (England) during the last eight years.

The nebulous wisps alluded to are that faint and diffused luminosity which, when viewed with increasingly high powers is sometimes resolved into stars, sometimes remains partially or wholly unresolved, and sometimes disappears altogether. With the naked eye the Milky Way has an appearance of resolvability, as if it was composed of stars which would be separately visible with a telescope; but though the telescope does to a great extent resolve it, whatever magnifying power is used there is visible an abundance of irresolvable nebulosity which does not give any suspicion of being composed of stars; and in all parts of the sky fainter patches of it may be seen. There are three conceivable causes of the appearance of such nebulosity: it may consist of luminous gas or dust which no magnifying can resolve; or of faint stars too close together to be resolved with the power employed; or may, perhaps, be only a subjective appearance—for, when resolved, the nebulosity in some cases shows very small and densely packed stars, but in others widely scattered stars not much too faint to be individually visible with lower power—and in this latter case the writer suggests that the nebulous appearance may be caused by the glow round the stars being sufficiently extended to impress itself upon the eye, though the individual stars, being mere points, are invisible; while they are sufficiently near together for the glow from each to overlap that from its neighbors, so that an appearance of continuous nebulosity is produced. These nebulous wisps, etc., are wanting in catalogues of nebulæ, but since such catalogues include many resolvable clusters the questions arise, why should this be, and where does nebulosity end and a nebula begin?

Curves of stars have often been noted in the heavens; but in large portions of the observed area a parallel arrangement of the stars and an arrangement in straight lines, are by far the most striking feature; the irresolvable wisps (which are usually long and narrow) to a great extent falling in with the same arrangement as the stars. The portions of the area where the different parallelisms exist are in some cases very abruptly bounded, but in others cease gradually. Sometimes the parallelism reappears after a space where it is not perceived. In some cases the same stars

form lines belonging to more than one parallelism; it is possible that such instances are by mere chance, and that the star belongs really to only one. Of course, if one star belongs to two parallelisms, such is an indication that those two systems are in the same region of space, but it would be more natural to expect that the different parallelisms observed are in widely different regions, one being seen behind another. In Argelander's "Atlas des nördlichen gestiruten Himmels" the same lines are perceptible very often, but not in all cases; though several instances of parallel arrangement can be detected that escaped the use of the field-glass upon the sky, although that instrument appears to show stars down to nearly the same magnitude as are included in the Atlas. This difference in the results of the two examinations may be partly owing to the circumstance that often two or more stars close together may each be too small to be entered in the maps, but their united light may be impressed upon the eye; and, on the other hand, that the appearance of a line may be destroyed by the addition of somewhat fainter surrounding stars.

There is, besides the parallelisms, a most wonderful case of *radiation of stars and wisps* in a fan-shaped group, 68 Orionis being approximately the centre. The only counterparts to this which the writer has seen are the two following: On a far larger scale there is a radition, visible to the naked eye, from near the Pole star, to the Milky Way in the semicircle from ε Ursæ Minoris to β Camelopardi. This consists of stars and wisps. 2. A recent examination of Professor Barnard's photograph of the region around 11 Messier (in Aquila) shows lines of stars and dark lanes forming a not well-marked radiation, but, with little exception, it only subtends an angle of 50° or 60° from the point whence it radiates (in R. A. $18^h\ 50^m8$, Dec. $-9°.9'$, for 1880). These two radiations are so much less marked than that from 68 Orionis, that it is quite doubtful whether they are more than an accidental appearance caused by a combination of adjacent parallel systems; but it seems highly improbable that such an explanation can be given to the radiation form 68 Orionis. If on further examination of the sky other examples are found, it may be possible to establish the radiated form as one of the recognized systems in the structure of the heavens.

From an investigation into the position-angles of the various systems of lines and wisps, it is apparent that they are grouped more numerously in certain directions than in others; the principal directions being nearly parallel with the galactic equator, or axis of the Milky Way. There is a marked deficiency of position-angles about at right-angles to the galactic equator; it is, perhaps, only a coincidence that this latter remark applies not only to the wisps and streams of stars in the area generally, but also to the lines in the great cluster in Gemini (35 Messier), which was examined with a 4¼-inch refractor, as well as in the MM. Henry's photograph of that object; the lines in the other clusters in the area, which were examined with the telescope, favor no particular direction.

It is manifest that so extensive an arrangement of stars in parallel lines cannot be the result of chance, and it is probable that those parallel to one another are in the same region of space. It therefore follows that the majority of the brighter stars in extensive tracts of the area we have been considering are really near one another. The only hypothesis that would not lead to such a conclusion is to suppose that there is a general tendency of all the stars in the sidereal universe to be grouped in parallel planes, in the same way as there is a tendency of the secondary systems in the solar system to be so. If this tendency existed, we should expect these planes to be parallel to the axis of the Milky Way; and we find the most prevalent direction of the lines in the area under consideration is nearly this. But this will not explain why there should be other systems of parallel lines. Then, as the irresolvable nebulosity lies so often in the same direction as the lines of stars, it must really be among them; and whether it contains any true nebulous matter or not, at least stars varying very greatly in magnitude must be associated together, so that these observations agree with Sir J. Herschel's on the Nubecula Major, and with Proctor's and Herbert Spencer's theories.

The bearing of this on the question of relative parallax is obvious and important; for if the conclusions arrived at are sound (without impugning the fact that difference of proper motion is often an indication of want of connection between stars), it would appear that if we take at random *any two stars* lying near together—say within a quarter of a degree

of each other—in the area of the sky that has been examined if not elsewhere, the chances are *much greater* that they are really near together than that they are far apart. *When two stars in the same neighborhood are found to have no appreciable relative parallax, this is not the slightest evidence of their remoteness from the earth,* it being just as likely the absence of relative parallax is owing to their proximity to one another.

The details of the before mentioned observations are scarcely suitable for, and would take up too much space in, the SIDEREAL MESSENGER; they have been tabulated and are to be printed separately, together with maps and diagrams, for distribution to those interested in the subject, and there will be much pleasure in forwarding copies to those who address the writer to this effect.

Sunderland, England, July 7, 1890.

TABLE OF STELLAR PARALLAXES.

In the February number of *Knowledge* will be found a very useful article by Herbert Sadler under the title, "List of Stellar Parallaxes." In that list is given the ordinary designation of the star, the approximate places for 1890, the magnitude roughly to the nearest half, in the photometric scale, the name of the observer or publisher of the determinations; the date, if marked with an asterisk the date of publication; the method of observation, the aperture of the instrument employed; the reference to the place of publication, and the actual parallax and probable error as determined by the observer. It may be useful to remark that the distance in light-years can be found by the use of the formula $\frac{3.2588}{P''}$, which cosresponds to a parallax of 8″.80, P being the parallax of any star under consideration. If the parallax be 8″.848, the formula then would be $\frac{3.24110}{P''}$.

By a recent letter from Mr. Sadler we received some corrections to the data as given in the article in *Knowledge*, which we have applied as he kindly suggested. We also take the liberty of putting the principal part of this interesting matter in tabular form, thinking that the respective data may be in a little more convenient form for reference and comparison. We have used great care to get all the matter correct as represented in the original article.—EDITOR.

Star.	Parallax and Probable Error.		Kind.	Astronomer.	Instrument.	Reference.
	″	″				
β Cassiopeiæ	+ 0.162	± 0.051	R	Pritchard	Phot. Plates	M. N. vol. XLIX. No. 1.
" "	+ 0.154	± 0.035	R	"	" "	Oxford Univ. Observ. Part III 1887–88.
34 Groombridge	+ 0.307	± 0.0376	A	Auwers	Filar M.	Berlin Academy, 1867.
ζ Tucanae	+ 0.06	± 0.02	R	Elkin	Heliometer	Mem. R. A. S., vol. XLVIII, Part I.
α Cassiopeiæ	+ 0.071	± 0.040	R	Pritchard	Phot. Plates	M. N. vol. XLIX, No. 1.
" "	+ 0.036	± 0.023	R	"	" "	Oxford Univ. Observ. Part III 1887-88.
η Cassiopeiæ	+ 0.154	± 0.045	R	O. Struve	Filar M.	Bulletin physico-math. Ac. Sc. Petersbourg, vol. XIV., p. 231.
" "	+ 0.3743	± 0.0723	R	Schweizer-Socoloff	" "	Annals of Obs. of Moscow vol. VIII, Part II, p. 89.
γ Cassiopeiæ	− 0.014	± 0.047	R	Pritchard	Phot. Plates	M. N. vol. XLIX, No. 1.
" "	+ 0.007	± 0.042	R	"	" "	" " " "
" "	− 0.025	± 0.031	R	"	" "	Oxford Univ. Observ. Part III 1887–88.
" "	+ 0.050	± 0.036	R	"	" "	" " " "
μ Cassiopeiæ	− 0.12	± 0.29	R	Bessel	Transit Inst.	Bessel Abhandlungen vol. II, p. 216.
" "	+ 0.342	± 0.052	R	O. Struve	Filar M.	Bulletin physico-math. Ac. Sc. Petersbourg, vol. XIV, p. 231.
" "	− 0.1432	± 0.1146	R	Schweizer-Socoloff	" "	Annals of Obs. of Moscow vol. VIII. Part II, p. 89.
" "	+ 0.036	± 0.025	R	Pritchard	Photo. Plates	M. N. vol. XLIX, No. 1.
Nova Andromedæ	− 0.32	± 1.12	R	Franz	Heliometer	A. N. No. 2816 (very doubtful).
" "	− 0.11	± 0.14	R	"	"	" " "
" "	Insensible.		R	Hall	Filar M.	
α Ursæ Minoris	+ 1.31		A	Piazza-Cacciatore	Transit Inst.	Præcipuarum Stellarum inerantium, Pos. Med.
" "	+ 0.24		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 38.
" "	+ 0.144	± 0.032	A	Von Lindenau		B. J. 1820.
" "	+ 0.60	± 0.12	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 175.
" "	+ 0.075	± 0.034	A	W. Struve	Transit Inst.	" " " "

Star.	Parallax and Probable Error.		Kind.	Astronomer.	Instrument.	Reference.
	″	″				
α Ursæ Minoris	+ 0.172	± 0.027	A	W. Struve and Preuss	Mer. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 65.
" "	+ 0.147	± 0.030	A	" " "	" "	" " " "
" "	+ 0.067	± 0.012	A	C. A. F. Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.068	± 0.012	A	Glasenapp	Rediscussion of Peters Results.	(Refraktsionnya oklony.)
" "	+ 0.015	± 0.015	A	L. De Ball	Mer. Circle	A. N. No. 2667.
" "	+ 0.073	± 0.014	R	Pritchard	Phot. Plate	M. N. vol. XLIX, No. 1.
" "	+ 0.079		R	"	" "	Oxford Univ. Obs. Part III.
ε (Lac. 1060) Eridani	+ 0.14	± 0.02	R	Elkin	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
P iii 242	+ 0.045	± 0.070	R	Sir R. Ball	Filar M.	Dunsink Observations, Part V, p. 226.
o^2. (40) Eridani	+ 0.166	± 0.018	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" "	+ 0.223	± 0.020	R	Hall	Filar M.	Wash. Observations, for 1883 App. II.
α Tauri	+ 1.5		A	Piazzi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 30.
" "	+ 0.516	± 0.057	R	O. Struve-Sludanow	Filar M.	M. N. vol. XLIV, p. 237.
" "	+ 0.102	± 0.0296	R	Hall	" "	Gould's Astr. Journal, No. 156.
" "	+ 0.116	± 0.029	R	Elkin	Heliometer	Report of Yale Univ. Observ.
α Aurigæ	+ 0.046	± 0.200	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.305	± 0.043	R	O. Struve	Filar M.	Bulletin physico-math. Ac. Sc. Petersbourg, vol. XIV, p. 234.
" "	− 0.087	± 0.130		"	" "	From measures of distance.
" "	+ 0.362	± 0.048		"	" "	" " " pos. angles.
" "	+ 0.522	± 0.181	A	Glasenapp	Rediscussion of Peters' Result	Refraktsionnya oklony.
" "	+ 0.107	± 0.047	R	Elkin	Heliometer	Report of Yale Univ. Observ.
α Orionis	− 0.009	± 0.049	R	Elkin	Heliometer	Report of Yale Observatory.
α Argus (Canopus)	+ 0.03	± 0.030	R	Elkin	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
ψ^5 Aurigæ (Comes)	+ 0.111	± 0.034	R	Schur	Filar M.	A. N. No. 2723.

α Canis Maj.	+ 4.		A	Piazzi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, p. 31.
" " "	+ 0.23	± 0.10	A	Henderson and Maclear	Mural Circle	Mem. R. A. S. vol. XI, p. 248.
α Canis Maj.	+ 0.34	± 0.11		Henderson		
" " "	+ 0.16	± 0.09		Maclear		
" " "	+ 0.15	± 0.09	A	Peters-Maclear	Rediscussion of Maclear's Res.	Recueil de Mem. des Astr. de Pulkova, p. 64.
" " "	+ 0.193	± 0.087	A	Gylden-Maclear	Rediscussion of Maclear's Res.	Bulletin Ac. Sc. Petersbourgh, vol. VII. p. 370.
" " "	+ 0.43	± 0.099	A	Belopolsky-Wagner	Mr. Circle	A. N. No. 2888.
" " "	+ 0.27	± 0.10	A	Abbe-Maclear	Rediscussion of Maclear's Res.	M. N. vol. XXVIII, p. 6.
" " "	+ 0.370	± 0.009	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" " "	+ 0.407	± 0.018	R	Elkin	"	" " " " "
51-Hev. Cephei	+ 0.027	± 0.019	A	L. De Ball	Discussions of Wagner's Obs.	A. N. No. 2667.
α Geminorun	+ 0.198	± 0.062	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI, p. 20.
α Canis Minoris	± 3.		A	Piazzi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 31.
" " "	+ 0.240*	± 0.029	R	Auwers	Heliometer	A. N. No. 1415. * mean
" " "	+ 0.299	± 0.038	R	Wagner	Mer. Circle	Mem. of Acad. of St. Petersburg, Series 7, vol. XXXI, Part II.
" " "	+ 0.266	± 0.047	R	Elkin	Heliometer	Report of Yale Coll. Observatory.
β Geminorum	+ 0.068	± 0.047	R	Elkin	Heliometer	" " " " "
ι Ursæ Majoris	+ 0.133	± 0.106	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, p. 136.
" " "	+ 0.127	± 0.106	A	Glasenapp	Redis. of Peters' Results	Refraktsionnya oklony.
10 Ursæ Maj.	+ 0.20	± 0.11	A	Belopolsky-Wagner	Mer. Circle	A. N. No. 2888.
Struve 1321 prec.	+ 0.087	± 0.021	R	Kapteyn	" "	" " 2935.
δ Ursæ Maj.	+ 0.046	± 0.029		Kapteyn	" "	" " "
Lal. 19022	+ 0.072	± 0.020		Kapteyn	" "	" " "
30 Leon. Min.	+ 0.071	± 0.028		Kapteyn	" "	" " "
α Leonis	+ 0.093	± 0.048	R	Elkin	Heliometer	Reportof Yale Coll. Observatory.
Groombridge 1618	+ 0.334	± 0.036	R	Sir R. Ball	Filar M.	Dunsink Observations, Part V, p. 197.

Star.	Parallax and Probable Error.		Kind.	Astronomer.	Instrument.	Reference.
	"	"				
Groombridge 1618	+ 0.177	± 0.023	R	Kapteyn	Filar M.	Dunsink Observations, Part V, p. 197.
" 1646	+ 0.109	± 0.025	R	Kapteyn	Mer. Circle	A. N. No. 2935.
" 1657	+ 0.025	± 0.028	R	Kapteyn	" "	" " "
Lal. 20670	− 0.006	± 0.028	R	Kapteyn	" "	" " "
β Ursæ Maj.	+0.0102 to	+0.0114	A	Klinkerfues	Displ. of lines of Spec. by Huggins	Gesells 1873, No. XIII.
α Ursæ Maj.	+ 1.22	± 0.44	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 175.
Lal. 21185	+ 0.511	± 0.015	R	Winnecke	Heliometer	A. N. No. 1147.
" "	+ 0.501	± 0.011	R	Winnecke	"	Publ. der Ast. Gesells, No. XI.
" "	+ 0.434	± 0.028	R	Kapteyn	"	" " " " "
Lal. 21258	+ 0.262	± 0.011	R	Auwers	Heliometer	M. N. vol. XXIII, p. 75.
" "	[+ 0.271	± 0.11]	A			
	+ 0.260	± 0.020	R	Krueger	Heliometer	Acta Fennicæ Soc. Scientiarum, vol. VII, p. 390.
" "	+ 0.167	± 0.027	R	Kapteyn	"	" " " " "
Struve 1516	+ 0.28	± 0.04	R	Berberich	Filar M.	A. N. No. 2624.
" "	+ 0.199	± 0.050	R	Winnecke	" "	" " "
" "	+ 0.104	± 0.008	R	L. De Ball	Filar M.	Mem. Acad. de Belgique, vol. XLIX.
Œltz. Arg. 11677	+ 0.272	± 0.038	R	Geelmuyden	Filar M.	A. N. No. 2287. Also No. 2666.
Struve 1561 seq.	+ 0.047	± 0.026	R	Kapteyn	Mer. Circle	" " 2935.
Groombridge 1822	+ 0.018	± 0.031	R	Kapteyn	" "	" " "
Groombridge 1830	+ 0.226	± 0.141	A	Peters	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 1.058		R	Faye	Dif. of R. A.*	Comptes Rendus, vol. XXV, p. 141.
	+ 1.085	± 0.065		"	" "	" " " XXIII, p. 1078.
" "	+ 0.182	± 0.018	R	Wichmann and Schluter	Heliometer	A. N. No. 610.
" "	+ 0.034	± 0.031	R	O. Struve	Filar M.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 293.
" "	+ 0.08	± 0.027	R	Wichmann	Redis. of Schlurs & his own Obs.	A. N. No. 844.

* With a neighboring Star obtained with reflector of 13-inch aperture.

Groombridge 1830	+ 0.135	± 0.013†			
" "	+ 0.72	± 0.043‡			
" "	+ 0.141	± 0.013	R	Peters	(Redis. of obs. of Schluter and Wichman.) — A. N. No. 866.
" "	+ 0.148	± 0.013	[A]	Peters	
" "	+ 0.114	± 0.019	R	Wichmann	Quot. by Auwers — Monat der Akad. zu Berlin 1874, p. 591.
" "	+ 0.166	± 0.018	R	Schlvter	" " " " " " " " "
" "	+ 0.033	± 0.028	R	Johnson	Heliometer — Radcliffe Observations vol. XIV, p. 48.
" "	+ 0.023	± 0.033	R	Johnson	Redis. by Auwers — *Loc. cit.*
" "	+ 0.089	± 0.017	R	Brunnow	Filar M. — Dunsink Observations, Part II, p. 23.
" "	+ 0.262	± 0.141	A	Glasenapp	Redis. of Peters' Results. — Refraktsionnya oklony.
" "	+ 0.161	± 0.029		Kapteyn	Mer. Circle — A. N. No. 2935.
γ Ursæ Maj.	+ 0.39		A	Brinkley	Vert. Circle — Recueil de Mem. des Astr. de Pulkova, vol. I. p. 40.
"	+ 0.0164 to + 0.0183		A	Klinkerfues	Disp. of lines of spec. by Huggins — Gesells, etc., der Gottingen, 1873, No. 13, p. 357.
Lal. 22632	− 0.039	± 0.038	R	Kapteyn	Merid. Circle. — A. N. No. 2935.
Lal. 22810	+ 0.067	± 0.030	R	Kapteyn	" " " " "
δ Ursæ Maj.	+ 0.0244 to + 0.0271		A	Klinkerfues	Displ. of lines of spec. by Huggins — Gesells, etc., der Gottingen, 1873, No. 13, p. 357.
ε Urs. Maj.	+ 0.33		A	Brinkley	Vert. Circle — Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" " "	+ 0.41	± 0.35	A	Brioschi	" " " " "
" " "	+ 0.0301	± 0.0334		Klinkerfues	Disp. of lines spec. by Huggins — Gesells, etc., der Gottingen No. 13, p. 357.
ζ Urs. Maj.	+ 0.28		A	Brinkley	Vert. Circle — Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" " "	+ 0.429 to + 0.0477		A	Klinkerfues	Disp. of lines of spec. by Huggins — Gesells, etc., der Gottingen No. 13, p. 357.
α Virginis	− 0.42	± 0.33	A	Brioschi	Vert. Circle — Recueil de Mem. des Astr. de Pulkova. vol. I, p. 175.
η Ursae Maj.	+ 0.095		A	Brinkley	Vert. Circle — Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
β Centauri	+ 0.470	± 0.044	A	Maclear	Mural Circle — Mem. R. A. S. vol. XXI, p. 152.
" "	+ 0.213	± 0.069	A	Mœsta	Transit Circle — A. N. No. 1688.

† Another determination. ‡ By another method.

Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
	″ ″				
β Centauri	+ 0.173 ± 0.07	A	Mœsta	A fresh determination	A. N. No. 2349.
" "	− 0.018 ± 0.019	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
α Bootis	+ 1.1 ± 0.15	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 0.61	A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.652	A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.127 ± 0.074	A	Peters	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.169 ± 0.044	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI.
" "	+ 0.210 ± 0.073	A	Glasenapp	Redis. of Peters' results	S. Glasenapp. Refraktsionnya oklony.
" "	+ 0.018 ± 0.022	R	Elkin	Heliometer	Report of Yale College Observatory.
α Centauri	+ 1.14 ± 0.11	A	Henderson	Mural Circle	Mem. R. A. S. vol. XI, p. 68.
" "	+ 0.913 ± 0.064	A	Henderson-Maclear	2 Mural Circles	" " " XII, p. 370.
" "	+ 0.976 ± 0.064 with other corrections + 0.49	A	Peters-Maclear	Redis. Maclear's results	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 63.
" "	+ 0.880 ± 0.068	A	Mœsta	Transit Circle	A. N. No. 1688.
" "	+ 0.521 ± 0.066	A	Mœsta	A fresh determination	" " 2349.
" "	+ 0.512 ± 0.080	A	Elkin-Maclear	Redis. Maclear's results	Uber die Parallax von α Centauri.
" "	+ 0.76 ± 0.013	R	Gill	Heliometer	Mem. R. A. S. vol. XLVIII, Part I.
" "	+ 0.676 ± 0.027	R	Elkin	"	Loc. cit.
β Ursæ Min.	− 0.38 ± 0.37	A	Brioschi	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, p. 175.
η Herculis	+ 0.40 ± 0.072	A	Belopolsky-Wagner	Transit Circle	A. N. No. 2888.
α Herculis	+ 0.586	R	Bessel	Reflector	Briefwechsel mit Olbers, vol. I, p. 47.

α Herculis	+ 0.061 ± 0.008	R	Jacob	Filar M.	Madras Observations, vol. VII. Appendix, p. 20.
π Herculis	+ 0.11 ± 0.063	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
α Ophiuchi	+ 1.57	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova.
ν Draconis	+ 0.32 ± 0.076 preceding star	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
	+ 0.28 ± 0.088 following star		" "	" "	" " "
17,414 Œltz Arg.	+ 0.247 ± 0.0211	R	Krueger	Heliometer	Acta Fennicæ Soc. Scientiarum, vol. VII, p. 383.
" " "	+ 0.1914 ± 0.030	R	Schweizer-Socoloff	Filar M.	Annales de l'Observatoire de Moscow, vol. VIII, Part II, p. 90.
γ Draconis	− 0.08	A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.0704	A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.05	A	Pond	Mural Circle	Ph. Trans. vol. CVII, p. 170.
" "	− 0.242	A	Main	Reflex Zenith Tube	Mem. R. A. S. vol. XXIX, p. 189.
" "	− 0.131 ± 0.041	A	Downing	Reflex Zenith Tube	M. N. vol. XLII, p. 344.
Nebula Herschel	+ 0.009 ± 0.041	R	Bredichin	Filar M.	Annales de l'Observatoire de Moscow, vol. III, Part IV.
" "	+ 0.047 ± 0.030	R	Brunnow	" "	Dunsink Observations, Part III, p. 6.
70 Ophiuchi	+ 0.169 ± 0.010	R	Krueger	Heliometer	A. N. No. 1212.
	+ 0.162 ± 0.007	R	"	"	" " 1403.
δ Ursæ Min.	+ 0.203 ± 0.037	A	W. Struve	Transit	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 55.
" " "	+ 0.034 ± 0.017	A	L. De Ball	Disc. Wagner's Obs. with mer. cir. 1861-72	A. N. No. 2669.
α Lyræ	+ 3.9	A	Calandrelli	Sector	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 33.
" "	+ 1.26	A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 38.

Star.	Parallax and Probable Error.		Kind.	Astronomer.	Instrument.	Reference.
	″	″				
α Lyræ	+ 0.66	± 0.08	A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 1.21		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 1.138		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 41.
" "	+ 0.37	± 0.29	A	Brioschi	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 175.
" "	+ 0.007		A	Pond	Tran. mur. cir.	Ph. Trans. vol. CVII, p. 170.
" "	+ 0.224		A	Airy	Mural Circle	Mem. R. A. S. vol. X.
" "	− 0.092		A	"	" "	Loc. cit.
" "	+ 0.262	± 0.025	R	W. Struve	Filar M.	Additamentum in Mens. Micr.
α Lyræ	+ 0.103	± 0.053	A	Peters	Vert. Circ.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	+ 0.147	± 0.009	R	O. Struve	Filar M.	Mem. Acad. St. Petersbourg, series VII, vol. I, p. 50.
" "	+ 0.137		A	"	" "	Mem. Acad. St. Petersbourg, series VII, vol. I, p. 50.
" "	+ 0.154	± 0.046	R	Johnson	Heliometer	Radcliffe Observations, vol. XVI, p. 30.
" "	+ 0.212	± 0.010	R	Brunnow	Filar M.	Dunsink Observations, Part I, p. 29.
" "	+ 0.131	± 0.033	R	"	" "	" " " II, p. 55.
" "	[+ 0.188	± 0.033]	R	"	" "	" " " II, p. 57.
" "	+ 0.134	± 0.006	R	Hall	" "	Washington Observations for 1883, Appendix II.
" "	+ 0.110	± 0.050	A	Glasenapp	Redis. of Peters' results	Refraktsionnya oklony.
" "	+ 0.034	± 0.045	R	Elkin	Heliometer	Report of Yale College Observatory.
Œltz Arg. 18609	+ 0.34	± 0.34	R	Lamp	Filar M.	A. N. No. 2676.
" " "	+ 0.353	± 0.014	R	"	" "	" " 2808.
Cygni 6 (Bode)	+ 0.482	± 0.054	R	Sir R. Ball	" "	Dunsink Observations, Part V, p. 238.
" "	− 0.021	± 0.008	R	Hall	" "	Washington Astr. Observations 1883, App. II, p. 42.

δ Aquilæ	+ 3.20		A	Brinkley	Vert. Cir.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
σ Draconis	+ 0.222	± 0.022	R	Brunnow	Filar M.	Dunsink Observations, Part I, p. 44.
" "	+ 0.262	± 0.20	R	"	" "	" " " II, p. 30.
γ Aquilæ	+ 2.19		A	Brinkley	Vert. Circle	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
α Aquilæ	+ 2.53		A	Brinkley	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 1.57		A	"		Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 1.731		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	+ 0.078		A	Taylor	Mural Circle	Madras Observations, vol. II, p. 132.
" "	+ 0.181	± 0.094		W. Struve(?)	Quoted by Elkin	Report of Yale University Observatory.
" "	+ 0.199	± 0.047	R	Elkin	Heliometer	" " " " "
β Aquilæ	+ 2.36		A	Brinkley	Vert. Circle.	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
α Cygni	+ 0.78		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 39.
" "	+ 0.33		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 40.
" "	+ 0.50		A	"	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 42.
" "	− 0.082	± 0.043	A	Peters	" "	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 136.
" "	− 0.059	± 0.043	A	Glasenapp	Redis. of Peters' results	Refraktsionnya oklony.
" "	− 0.042	± 0.047	A	Elkin	Heliometer	Report of Yale Observatory.
61 Cygni	+ 0.55		A	Arago et Mathieu	Repeating cir.	Annaire du Bureau des Longitudes 1834, p. 281.
" "	+ 0.47	± 0.51	A	Lindenau reduced anew by Peters	Transit	Recueil de Mem. des Astr. de Pulkova, vol. I, p. 48.
" "	− 0.88	± 0.19	A	Bessel	Transit	Peters loc. cit.
" "	+ 0.3483	± 0.009	R	Bessel & Schluter	Heliometer	Peters op. cit. p. 60.
	[+ 0.3136	± 0.014]		Bessel		
" "	+ 0.349	± 0.080	A	Peters	Vert. Circle	Peters op. cit. p. 136.

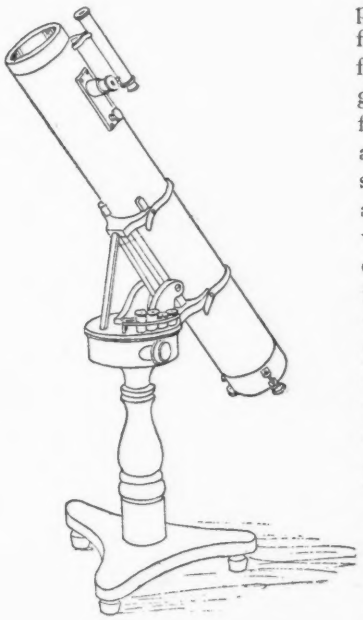
Star.	Parallax and Probable Error.	Kind.	Astronomer.	Instrument.	Reference.
" "	+ 0.402 ± 0.016	R	Johnson	Heliometer	Radcliffe Observations, vol. XIV, p. 39.
61 Cygni	+ 0.506 ± 0.028	R	O. Struve	Filar M.	St. Petersbourg Acad. Mem., vol. VII, p. 51.
" "	+ 0.360 ± 0.012	R	C. A. F. Peters	Redis. of Bessel's and Schluter's results	A. N. No. 866.
" "	+ 0.566 ± 0.016	R	Auwers	Heliometer	M. N. vol. XXIII, p. 75.
" "	+ 0.525 ± 0.093	A	Belopolsky-Wagner	Merid. Circle	A. N. No. 2888.
" "	+ 0.4330 ± 0.2091	R	Schweizer-Socoloff	Filar M.	l'Observatoire de Moscow, vol. VIII, Part II, p. 90.
" "	+ 0.465 ± 0.049	R	Sir R. Ball	" "	Dunsink Observations, Part III, p. 27.
" "	+ 0.468 ± 0.032	R	" " "	" "	" " " V, p. 166.
" "	+ 0.430 ± 0.049	A	Glasenapp	Redis. of Peters' Results	Refraktsionnya oklony.
" "	+ 0.270 ± 0.010	R	Hall	Filar M.	Washington Observations 1883, App. II.
" "	+ 0.432 ± 0.437	R	Pritchard	Photo. with Reflector	M. N. vol. XLVII, p. 445.
α Cephei	+ 0.061	R	"	Photo. with Reflector	Oxford University Observations, Part III.
ε Indi	+ 0.27 ± 0.02	R	Gill	Heliometer	Mem. R. A. S., vol. XLVIII, Part I.
" "	+ 0.12 ± 0.19	R	Elkin	"	Report of Yale Observatory.
Lac 9352	+ 0.285 ± 0.02	R	Gill	"	Mem. R. A. S., vol. XLVIII, Part I.
Bradley 3077	+ 0.069 ± 0.27	R	Brunnow	Filar M.	Dunsink Observations, Part II, p. 49.
" "	+ 0.205 ± 0.079	A	Backlund-Wagner	Transit Circle	Copernicus vol. II, p. 202.
" "	+ 0.283 ± 0.047	R	Gylden	Filar M.	Stockholm Akad. Ofversigt, 1882.
85 Pegasi.	+ 0.054 ± 0.019	R	Brunnow	" "	Dunsink Observations, Part II, p. 42.

HOW A TELESCOPE MIRROR IS GROUND, POLISHED AND FIGURED.

GEORGE S. JONES.

For THE MESSENGER.

The "silver-on-glass" reflecting telescope has of late years been high in favor with amateur astronomers, particularly in England. Its mirrors of pure silver—the glass being merely the mould or form on which the mirrors proper rest —reflect nearly as large a percentage of the light as finds its way through the four surfaces of an object glass; it is entirely free from the defect of "chromatism," which cannot be said of the best "achromatic," and with careful workmanship it may be corrected perfectly for spherical aberration, — points which render it for most purposes a formidable rival of the more common refractor. No more clean and clear-cut views of a celestial object can be had than may be obtained with a good reflecting telescope.



But aside from the intrinsic merits of the reflector as now made, that which recommends it especially to amateurs, who are apt to be persons of limited means, is its comparatively small cost, or to look at this feature from a different point of view, the simplicity of its construction, which renders it quite practicable for one who has a fair amount of mechanical skill to make his own telescope. A mirror is a far less complicated piece of work than an achromatic object glass. It has but one surface to grind and polish, whereas an object glass has four, the curvatures of

all of which must be made to conform very exactly to the requirements of a previously prepared mathematical formula. Furthermore, since the surface only is used, the light not passing through the glass, it is not necessary to use for it expensive optical glass, but only glass that is of a homogeneous density, and is fairly free from air bubbles, will answer the purpose. When the one surface has been polished and brought to the right figure, the work is done. The silvering of the glass is a very simple matter; and the cost of silvering is a mere trifle.

The description which we shall give of the process of making one of these glass mirrors is based upon the writer's personal experience in an amateur way. It is hoped that it will not merely serve to satisfy a curiosity as to how work of this kind is done, but that it may be of some service to others who may be disposed to try in this direction the cunning of their own hands. Complete success may not come with the first trial; but with perseverance it will come in the end, and it will be worth the cost of a few failures.

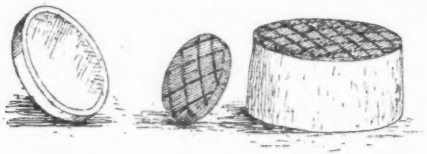
With the theory of the reflecting telescope the reader may be presumed to be acquainted. At any rate he can easily inform himself on this point from any work on optics. It is sufficient to say that the form of reflector now commonly used is the Newtonian, in which the image formed by the large concave mirror is thrown out at one side of the tube, near its upper end, by means of a small plane mirror or "flat," and in this position is magnified with an eye-piece of the same kind as is used with a refracting telescope.

To describe the process of making this concave mirror, we cannot do better, perhaps, than to take the reader directly into our workshop and give him the actual history of a 6¼-inch mirror, which he may see, in imagination, lying upon the table, only recently finished and still unsilvered. It may be well to say in advance, however, that in the more delicate parts of the work of making a mirror, particularly in the figuring or shaping of it, after the polishing is completed, different artists have employed different methods, and in some instances have left on record their want of success with the methods recommended by others. Our own experience has not been exceptional in this respect. The methods to be described below are simply those which, after many trials, have been found to yield the best results.

The disc for this mirror was of ordinary rough plate glass, 6¾ inches in diameter and about one inch in thickness. The grinding being the least difficult as well as the least interesting part of the work, may be disposed of in a few words. The rough disk was first ground with emery and water upon a flat plate of iron until its two faces were smooth and parallel; its edge was then trued by grinding in a lathe, specially adapted to this purpose, after which it was laid upon a table and its upper surface was hollowed out roughly to the required depth by vigorously scrubbing it with an iron tool fed with emery and water. The rough grinding done, the work was continued with a thick disc of cast iron, five inches in diameter, one face of which had been carefully turned in a lathe to the required convexity and afterwards grooved into squares of one inch. The curvature of the face of this tool, which was also to be the curvature of the mirror, had a radius of ten feet, it being designed that the mirror should have a focal length of five feet. As the grinding progressed emery of a finer and finer grade was used, the finishing touches being given with the very finest flour of emery obtainable by a process of elutriation, which need not be here described. In the fine grinding the greatest care is necessary to avoid scratching; but the reader can be spared the recital of such mishaps. It may be said here, parenthetically, that when two surfaces are ground together, the abrasion is caused by the rolling of the hard particles of emery between them and not by scraping, as upon a grindstone or an emery wheel. It is only when a too coarse particle of emery becomes lodged in some part of the tool that a scratch is produced, and it is to facilitate the escape of such particles that the grooves, before mentioned are made on its face.

The work of grinding is finally completed successfully, we will suppose. The surface of the glass is free both from scratches and from the nicks made in it by the coarse grinding; its curvature is perfectly spherical; it is as smooth to the touch as though it were already polished, and it will reflect the light of a gas jet at an angle of 45°; it is ready to be polished. The curvature of such a mirror, it may here be said is less than the reader may, perhaps, imagine. A "straight edge" laid across it is at the center no more than .04 of an inch above the surface.

The polishing is done with rouge, mixed with water, upon a tool of wood or iron, the surface of which is covered to the depth of an eighth of an inch, or more, with pitch. Like the grinding tool the polisher is cut into squares, in order to allow the pitch, which should be soft enough to yield gradually in the process of polishing, a chance to spread uniformly. The tool used with this mirror was a heavy circular block of wood, eight inches in diameter, experience indicating this as the proper size. If the polisher is too small, the polishing will proceed faster in the center of the mirror than at the border; if too large the reverse. With the polishing begins the really difficult work. To brighten



MIRROR. GRINDING TOOL. POLISHER.

the surface of the glass by scrubbing it backward and forward and round and round over the rouge-covered polisher is, indeed, easy enough, although a work of time, and with a little care the glass need not be scratched. But something more than a bright surface is required. The novice at this work will certainly spoil his first mirror; probably also his second and third. His chief misfortune will be that he will polish it into rings of different curvature. When he finishes his work, he will find that his mirror, if he is able to test it, has no regular figure; it is not spherical; it is not parabolic, it is not hyperbolic; it exhibits a combination of curves of different radii, and bright as it may be, it is, for the purpose for which it is designed, absolutely worthless. The only sure remedy in this case—it is hard, but it will save time in the end—is to put on the grinding tool again and take a fresh start. In time the learner will discover and correct the faults in his manipulation; but rules and directions given by another are of very little service.

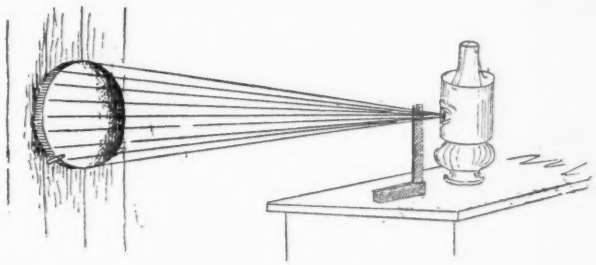
The mirror in question having been polished by one who had gone through the hard school of experience, came from the polisher in a satisfactory shape. Its figure was, how-

ever, by no means that desired, although it was one which could easily be corrected. The process of testing and correcting a mirror is, perhaps, that part of the work in which the reader will be the most interested; but it is hardly possible, without the aid of elaborate diagrams, to give a very clear idea of this process. Let us first see what figure is required. If a mirror of a perfectly spherical surface be made to reflect perfectly parallel rays of light, for example the rays of light coming from a star, those rays which strike near the center of the mirror will be so reflected as to come to a point or "focus" exactly half way between the center of curvature of the mirror and its surface; those which strike the mirror near its edge will be brought to a focus a little before they reach this central point, and the rays from other parts of the mirror will be focussed at points between these two extremes. The difference between the focus of the central and that of the outside rays of a spherical mirror is technically called its "aberration." In the case of a 6-inch mirror of five feet focal length, the aberration is a little less than .02 of an inch. This may seem a trifling matter, and, indeed, if we use an eye-piece of one or two inches in focal length, giving a low power, so slight a failure to focus exactly would not seriously mar the mirror's performance, but if we wish for a high power and use an eye-piece of no more than one-eighth or even one-quarter of an inch focus, it can easily be understood how an aberration even of one-fiftieth of an inch would render the image, thus highly magnified, blurred and indistinct in all its more minute details. A good "definition" with such a mirror would be an impossibility. The remedy is either to shorten the focus of the central rays by polishing out the central part of the mirror, giving it more curvature here, or to lengthen the focus of the outside rays by giving to the outer portion of the mirror less curvature. Upon the accuracy with which this correction of the figure is made will depend the value of the mirror. If the figure is perfectly corrected, all the rays of light from a distant luminous point will be brought to the same focus, and the image formed by an agregation of such points will be so sharply defined that it may be magnified to any desired extent, that is, until a limit is reached beyond which, owing to deficiency of light, magnification ceases to be of ad-

vantage. Such a figure, it is easy to show geometrically, is a section of a paraboloid. How exceedingly delicate must be the work of producing it, may be judged from a calculation, made by Sir William Herschel, that to give to a four-foot mirror whose curvature is perfectly spherical a parabolic curvature, it is necessary to polish off from the part near the circumference a layer of metal less than one twenty-thousandth part of an inch in thickness. With the most delicate measuring instruments it would, of course, be impossible to detect so slight a departure as this from the true spherical figure. This can be done only by means of optical tests, and of these there are several, the most beautiful of which, discovered by Foucault, is about to be described. By the Foucault method we are enabled to determine the exact figure of a mirror by simple inspection, all the features of its surface being exhibited in a highly exaggerated form; and it may be remarked here that had Herschel possessed this test, he would, no doubt, have been spared many a weary hour of labor, while working almost blindly to improve a mirror without knowing exactly where its defect lay.

The method of testing is this: The mirror is suspended against the wall of a darkened room, at a convenient height from the floor, and at the center of curvature—in the present case at a distance of ten feet from the mirror—is placed a lamp provided with a metal screen, in which, directly opposite the flame, are punched two or three holes of different sizes. The largest of these is a mere pin-hole; the smallest, the most minute which can be made with the point of a fine cambric needle. The light radiating from these holes, falling perpendicularly upon the mirror, is reflected back and forms optical images of them, which, by properly setting the mirror, may be brought a few inches to one side of the lamp, so that they can be magnified and examined with a lens or, better still, with a telescope eye-piece. If the mirror has a perfectly spherical curvature, these images will be seen sharply defined, as in a microscope, with no tails of light nor diffused illumination about them, all their ragged edges being distinctly visible. This is a good test to begin with and it will give us some idea of the condition of our mirror; but it is far less delicate than the Foucault test referred to above, which is now universally employed. To apply this

test, remove the eye-piece and place the eye eight or ten inches back from the focus. The holes will be seen as luminous spots, apparently on the mirror but in reality ten feet in front of it. Selecting the largest of them, keep it steadily in sight, while the eye is slowly moved towards the focus. The bright spot becomes blurred; it enlarges to a luminous blotch on the mirror, and finally, when the eye has been brought to within an inch or less of the focus, the whole surface of the mirror is seen suffused well with light. Now, keeping the eye steadily in this place, take a straight-edge in the right hand—a narrow strip of thin metal will answer for this purpose—and pass it slowly across the cone of light



THE TEST.

near the focus and between it and the mirror. As the straight edge, held perpendicularly, enters the cone of rays it is seen projected as a dark shadow on the right hand side of the illuminated mirror. Repeat the act, bringing the straight edge a little nearer to the focus. When it has been brought to a certain point, the shadow on the mirror ceases to be uniformly dark, as at first, but its inner edge becomes shaded and curved in such a manner as to give to the mirror the appearance of being a luminous ball, a foot or so in diameter. The illusion is perfect. As the straight edge is brought nearer and nearer to the focus, this deceptive appearance of convexity becomes less and less marked and finally, when it is passed across exactly at the focus, instead of a shadow making its appearance from one side, the illumination of the mirror gradually fades over all parts of its surface alike and the impression given is that it is perfectly *flat*. Continue the operation, passing the straight edge be-

tween the focus and the eye. The shadow now enters from the left side and the mirror appears to be concave. These are the appearances successively presented when the mirror is perfectly spherical. If it has some other figure,—if it is parabolic, or hyperbolic, or is full of rings, or has some other defect of curvature, a practiced eye will detect its faults at once by the appearance presented by the shaded surface. If, for example, it is parabolic, the figure desired, when the straight edge is inserted into the focus, the surface of the mirror, instead of appearing to be flat, will appear very slightly concave in the central part and convex near its circumference. If it is hyperbolic, that is more than parabolic, a similar appearance is presented but more exaggerated. In practice our mirrors have always come from the polisher with a hyperbolic figure. To bring them to a parabolic figure, it has been necessary to polish out the surface between the centre and the circumference. After many experiments we have found the best and safest polisher for this purpose to be the finger. The process requires the greatest care and the work must be examined every few minutes by the means above described. How delicate an operation it is can be imagined, when it is said that the warmth of the hand, held above the mirror in polishing, expands its upper surface to such an extent as very sensibly to change its figure. Each time that it is set up to be tested, an interval of ten or fifteen minutes must be allowed to elapse to give it time to resume its normal shape.

When the figure of the mirror has in this way been so far corrected that, as tested by the Foucault method, it is thought to be very nearly parabolic, a second and final test is applied to it. We need here merely indicate the nature of this test, without going into all its details. It is based upon the amount of the aberration in the case of a parabolic mirror, when it is made to reflect light radiating from the center of curvature. To confine our attention to the case in hand, it can be shown geometrically that, were this mirror of a parabolic figure, so that parallel rays from a very distant luminous point would all be brought to the same focus at a distance of five feet from its face, the rays from a point at ten feet distant would be so reflected that, while the central rays

would return exactly to the starting point, the focus of the outside rays would fall about .08 of an inch beyond. With this fact to work upon, an eye-piece is now brought into use, so mounted that by means of a lever it can readily be adjusted to .001 of an inch. The problem now is to make the mirror conform to its theoretical performance in its present position, supposing it to be parabolic. Three or four card-board screens are prepared, at the center of one of which is cut a hole an inch and a half in diameter and in the others, circles of a quarter of an inch in breadth and of different diameters. These screens are successively suspended in front of the mirror. By this means the central part of the mirror and a series of concentric circular sections of the rest of its surface may be examined separately, the proper focus of each section having been previously ascertained and marked upon an index card. The Foucault test also is used in connection with this, as it affords the best means of determining the regularity of the curvature and of detecting any local defects.

Our mirror, having been brought finally to respond satisfactorily to all these tests, was put again on a large polisher and was smoothed by a half hour's careful polishing. Being then laid aside for some hours, it was again tested and its performance being still satisfactory, the work of polishing was decided to be completed. One thing further remained to be done. With the utmost care it is impossible to make the figure correct to the extreme edge. The mirror was, therefore, now placed face downward upon the iron plate with which we started, and a quarter of an inch of its edge was ground off, leaving the polished surface with a diameter of but 6¼ inches, surrounded by a narrow border of ground glass.

It will naturally be asked what a mirror of this size will do. The following trial was made of this. It was temporarily mounted, while still unsilvered; a slip cut from a newspaper was posted at a distance of 450 feet and the improvised telescope was directed toward it. By using an eye-piece which gave a power of 300 diameters, this slip of paper was "brought" to a distance of about 1½ feet from the eye. Notwithstanding that the illumination was very faint, the paper could be read as easily as though it had

been held in the hand at that distance in a dimly lighted room. Every letter and punctuation mark was sharply defined. When this mirror is silvered it will reflect about twenty times as much light as now, and its performance will not be considered satisfactory if it does not bear a power of at least 400 diameters upon such objects as the moon and the planets and of 500 upon stars. According to the formula of Dawes and Foucault it should separate a double star of which the components are no more than 0″.75 apart. But the actual performance of the best telescope rarely comes up to its theoretical powers and we may be content in this instance with a separating power of 1.″ This may be expressed more clearly by saying that if two small holes punctured in a plate of metal one-tenth of an inch apart were illuminated by a strong light placed behind the plate, they should be seen distinctly as two separate points of light at a distance of nearly one-third of a mile. The actual distance apart of the images of these holes at the focus of the mirror would be .0003 of an inch.

Sections of the Apparent Figure of a Mirror, tested by the Foucault Method. 1, Spherical; 2, Parabolic; 3, Hyperbolic; 4, Full of Rings.

A mirror is not a complete telescope, it is true, but it is the part most difficult to make. One who has succeeded with this part of the work, will have no trouble with the rest. To make a suitable tube, of wood or paper or sheet metal, to make a "flat" (like the large mirror made of glass and silvered) and to mount the instrument in some convenient way are comparatively easy matters. Eye-pieces can be purchased, if it is not convenient or desirable to make them.

Upon the making of the mirror, therefore, the first energies are to be expended. The description of the process given above is not designed to afford working directions; its purpose has been mainly to direct attention to a recognized field for amateur work and to exhibit the processes employed with sufficient fullness to show that they are really quite simple and such as almost anyone can hope to master with a little perseverance. Those who may wish for a more complete treatment of this subject, will find much use-

ful information in the article on *The Telescope*, by Sir John Herschel, in the *Encyclopedia Britannica*, and in Vol. XIV of the *Smithsonian Contributions* (1865), in which Professor Henry Draper gives a very complete account of the construction of a 15½ inch telescope, including a description of the process of silvering the mirror. In concluding, we advise the beginner not to be too ambitious, but to try his "prentice hand" on a mirror of no more than three inches in diameter, for which a disc of common plate glass ¼ or ⅜ of an inch in thickness will answer. A good telescope of so small an aperture even as this is by no means an instrument to be despised. The writer has a 3-inch reflector, of two feet focal length—so small an instrument as to appear almost as a toy—which bears a power of two hundred diameters. It gives very fine views of the lunar mountains, will show, with a fair amount of detail, the belts of Jupiter, the markings on Mars and the division in the ring of Saturn. With such an instrument one can examine any of the objects given in Webb's *Celestial Objects for Common Telescopes*.

THE RADIANT-POINTS OF METEORS.

W. H. S. MONCK.

For The Messenger.

Mr. Denning's Catalogue of Meteor-Radiants, published in the May number of the *Monthly Notices* of the Royal Astronomical Society, will, I believe, when fully examined, largely modify the views generally entertained by astronomers on the subject. It is, I believe, the most remarkable contribution to this branch of the science ever made (or likely to be made) by one man. The first point which it places in a clear light is the existence of stationary or long-continued radiants. Of these Mr. Denning now enumerates 45, and no small proportion of his 918 observed radiants belong to these 45 stationaries. But an examination of the catalogue leads me to think that the number of stationary radiants might be doubled without going beyond the limits of Mr. Denning's catalogue. It would occupy too much space were I to attempt to set out a detailed list of these additional stationaries. Some of them I shall have occasion to refer

to specially, but before doing so I shall give as an example one which I do not propose to use for any other purpose:

No. in Catalogue.	Radiant-Point.	Date.
433	70° + 66°	Aug. 21, 23.
477	70 + 65	Aug. 27, 29.
555	69 + 70	Sept. 17, 19.
672	70 + 65	Oct. 15, 20.
769	70 + 65	Nov. 13.
799	69 + 66	Nov. 19, 20.
856	70 + 67	Dec. 4, 8.

I think any one who will take the trouble of writing out Mr. Denning's catalogue, not in order of date but in order of right ascension or declination, will be satisfied that stationary or long-continued radiants are not the exception but the rule. I venture to put forward as a hypothesis that this is not merely the rule, but an invariable law, the exceptions being accounted for by the tenuity of certain showers and the want of sufficient observations. Thus, for instance, when the radiant is below the horizon, meteors from it are not likely to be observed; or when it lies to the west while the observer is looking east (as Mr. Denning generally did). Clouds and moonlight interfere with observations, and no observer is on the lookout every fine night, while Mr. Denning, with all his energy and perseverance seldom, if ever, watched through an entire night.

This hypothesis can hardly be reconciled with the cometary theory which is generally accepted, or with the shifting radiants which Mr. Denning thinks he has observed in several instances. I shall not, of course, altogether deny the influence of certain comets on certain meteor-showers but I think it is of a different character from what is generally supposed. In order to show this I shall endeavor to prove that the Perseid and Andromede radiants are stationary or long-enduring radiants which supply us with a considerable number of meteors when we are at a great distance from the comet's node.

PERSEID RADIANT.

(*Omitting the Numerous Observations in the First of August.*)

No. in Denning's Catalogue.	Radiant-Point.	Date.	
171	40° + 56°	June 14, 25.	
298	43 + 58	July 27, 31.	
422	40 + 59	Aug. 20, 21.	Mean Position
(Tupman)	(42 + 55)	(Sept. 5.)	44° + 56°
634	42 + 55	Oct. 6, 12.	
656	43 + 58	Oct. 8, 14.	
745	45 + 60	Nov. 7.	
830	44 + 56	Nov. 29.	
847	44 + 56	Dec. 1, 10.	

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This table suggests that Mr. Denning was in error in describing this radiant as a shifting one, and that it is in fact continuously active without any material change in position from June to December. Mr. Denning has, I think, confounded the meteors derived from this source with those belonging to three other stationary radiants which appear thus in his catalogue:

No. in Catalogue.	Radiant-Pt.	Date.	
FIRST STATIONARY RADIANT.			
188	3° + 49°	July 8, 11.	
199	6 + 53	July 12.	
219	5 + 52	July 16.	Mean Position
221	7 + 53	July 17.	6° + 52°
357	8 + 53	Aug. 10, 12.	
666	7 + 51	Oct. 15, 20.	
758	5 + 52	Nov. 10, 13.	
SECOND STATIONARY RADIANT.			
149	20° + 58°	May 30.	
260	18 + 58	July 28.	
278	21 + 57	July 20, Aug. 1.	Mean Position
320	20 + 58	Aug. 2, 4.	20° + 57°
521	20 + 56	Sept. 13, 22.	
652	21 + 55	Oct. 14.	
THIRD STATIONARY RADIANT.			
264	32° + 53°	July 27, 28.	
290	32 + 53	July 30, Aug. 1.	
311	33 + 55	Aug. 2.	Mean Position
443	32 + 50	Aug. 14, 23.	32° + 53°
514	33 + 54	Sept. 6, 9.	
587	31 + 52	Sept. 21, 25.	

Under the last of these heads I have omitted some of Mr. Denning's radiants which are nearly of the same date and value as those inserted.

These four radiants appear to be simultaneously active at the end of July and beginning of August, when they often seem to run into each other by imperceptible degrees, but in their later developments (as well as in the earlier developments of the principal radiant and that which I have described as the second stationary), they are easily distinguished, and I suspect that some radiants have been erroneously determined because meteors belonging to different neighboring streams happened to pass nearly through the same point. I desire to call attention to the fact that Mr. Denning has observed meteors from the radiants which I have described as the first, second and third stationaries in

the month of August throughout the whole of which month he ascribes a greater R. A. to the Perseids; in addition to which he has observed meteors from the true or principal Perseid radiant (44° + 56°) before the end of July. These facts seem to me to prove that we are dealing not with a shifting radiant but with several radiants which are in simultaneous action.

The Andromede shower of November 28 seems also to proceed from a fixed or stationary radiant, though Mr. Denning did not notice any meteors from it later than the principal shower. The following are the earlier appearances.

No. in Catalogue.	Radiant-Point.	Date.	
321	26° + 42°	Aug. 4, 10.	
401	22 + 46	Aug. 12, 16.	
411	25 + 42	Aug. 19, 21.	Mean Position
441	24 + 42	Aug. 21, 25.	25° + 44°
488	28 + 45	Sept. 4, 16.	
669	25 + 44	Oct. 14, 15.	
740	25 + 46	Nov. 4, 7.	
809	24 + 45	Nov. 25, 27.	

I think I am justified in concluding from these data, first, That the great majority of radiants are stationary or long-enduring. Second, that no shifting radiant has hitherto been conclusively proved; and third, that two at least of the supposed cometary showers proceed from stationary or long-continued radiants which are active even when the earth is a great distance from the node of the comet's orbit.

The question next comes, How can stationary radiants be explained? I venture to offer the following, not without some hesitation, as it has not been accepted by some mathematical friends to whom I communicated it.

Suppose, for illustration, that a river runs E. to W. with a raft floating down it close to the bank and that a number of balls are rolled over the bank in a direction N. to S. with a constant velocity, each of which rolls on to the raft. Now to a person on the raft the balls rolling across it seem to be travelling N. to S. no matter at what rate the raft is moving; for this person moves with the raft and is unconscious of his own motion. Again let the channel of the river take a bend to the N. the balls still seem to the man on the raft to move across it in the same direction (N. to S.) as before. The only difference is that the velocity is increased.

Let it now take a bend to the S. The direction of the balls is still unaltered. They only appear to roll across the raft with diminished velocity. In the case of the earth the atmosphere plays the part of the raft. It moves with the earth and the spectator moves with both. The meteor at the moment when it first becomes visible already partakes in the motion of the raft—that is of the air or of the earth; and as long as meteors reach us from the same direction we shall refer them to the same radiant. Stationary radiants therefore, simply mean that meteors come to us for months in succession from the same direction. The change in the earth's motion would not affect the apparent direction or radiant-point of the meteors but only their apparent velocity. And accordingly Mr. Denning notices that their apparent velocity *is* altered. Thus of a shower from another point in Perseus (47° + 44°) he says: "In July and August they move very swiftly and leave bright streaks. In September the motions are still very swift but the meteors are then devoid of streaks except in the more brilliant instances. In October the speed has palpably slackened, my description of the flights being 'moderately swift,' while in the middle of November I estimated them as 'rather slow.' At the end of that month and early in December my records give 'slow' and 'very slow,' and this also applies to the meteors of this radiant seen between December 18—January 11 and February 23—March 12" (*Monthly Notices* vol. 50, p. 416). This extract sufficiently disposes of the theory of the late Mr. Proctor that these radiants appeared to be stationary because the velocity of the component meteors was very great compared with that of the earth. Some of them are *very slow* according to Mr. Denning but their velocities vary at different times as on my hypothesis they ought to do. The earth is receding from the radiant in question when the observed motion is slow and approaching it when the observed motion is fast.

But how on this hypothesis can the influence of the comets on certain showers be explained. On this point I can only offer a conjecture. Suppose in the illustration already given that the balls are electrified and that suddenly a large oppositely electrified body moves down through them in a direction nearly N. to S. Evidently the effect will be to draw the balls toward the track of this large body and thus ren-

der them thicker near the track than at a distance from it; and thus even if the large body stops before reaching the bank of the river more balls will roll on to the raft at its point of nearest approach than elsewhere. The effect will be more marked if the large body crosses the river; and I may add that a slight shifting of the radiant might arise owing to the balls being drawn slightly out of their course by the attraction. Substituting gravitation for electricity the result is unaltered. A comet running through a meteor-cloud would cause the meteors to become thicker about its track and thinner outside of it and might also occasion a slight shifting of the radiant.

The changes in the velocity of the meteors referred to the four stationary radiants in Perseus are exactly what they ought to be on the hypothesis which I have now put forward. The early meteors from all four radiants are described as swift and usually as accompanied by streaks. At No. 521 (Sept. 13, 22) I first meet the word "slowish" No. 587 (Sept. 21, 25) is also "slow." And from this to the end all the streams are described as slow with two or three dubious exceptions. With the Andromedes also I find that while the meteors in the well-known November shower are slow the August meteors from the same radiant are described as swift, the September as rather swift and the October slow. In fact the meteors from every radiant in this part of the sky slacken their speed between August and November as they ought to do on my hypothesis.

In conclusion I may remark that the close agreement of the orbits of four meteor-showers with those of four known comets depends to a great extent on uncertain estimates of the velocities of the meteors. A swifter or slower motion would derange the supposed orbits materially and I suspect that the estimated velocity of the meteor has sometimes depended on theoretical considerations rather than actual observation. In the case of a large Andromede fireball which was observed at a number of different places some years ago, Col. Tupman, from the observations, computed an orbit differing considerably from that of Biela's comet, the eccentricity being small and the period only 462 days. This orbit is more consistent with the theory of Tschermak and Sir Robert Ball than with the cometary theory.

July 19, 1890.

XUM

VISUAL OBSERVATION OF THE SURFACE OF MARS.

WILLIAM H. PICKERING.

FOR THE MESSENGER.

In connection with the series of photographs of this planet taken upon Mt. Wilson, and referred to in the June number of THE MESSENGER, a careful series of visual obvisual observations have been made at Cambridge by the writer with the Boyden 12-inch refractor. The points to which especial attention has been directed are primarily the colors exhibited by the planet, and secondarily the delineation of the finer detail upon its surface. Regarding the latter there is no question but Green's map (Mem. Roy. Ast. Soc., Vol. XLIV., p. 123) gives much the best idea of the appearance of the planet and the general shape of the details of anything yet published. On the other hand there is considerable fine detail which is not given by Green, which is certainly seen in Cambridge, and which agrees more or less with that represented by Schiaparelli (Reale Accad. dei Lincei, 1886, Vol. III., p. 281). It seems to me most unfortunate that the name of canals has been attached to these finer markings upon the planet, for there has not been the slightest evidence brought forward in support of the supposition that they are filled with water, and such a supposition is, to say the least of it, very improbable.

The easiest one of all the canals to see is that shown by Green under the name of Nasmyth Inlet, and which Schiaparellli indicates by two very faint lines to which he gives in various portions of their length the names of Protonilus, Ismenius Lacus, Deuteronilus, and Jordanis. Schiaparelli's Boreosyrtis and Astapus are also readily seen. With these exceptions it was a long time before I could detect any of Schiaparelli's canals. This I afterwards found was in part due to my using too high a power, and in part to my eye being unaccustomed to the work. Now even when the seeing is only moderate, there is no difficulty in also seeing Styx, Fretum Anian, and Hyblaeus. Several other canals in this same region have been recognized, including Cerberus, Eunastos, Hephæstus, Alcyonius, Cyclops, and Laestrygon. These have all been discovered independently of the map,

and represented on at least two separate drawings. I have not yet been able to double any of them, or to see many of the fainter ones, but I have the highest admiration for the eyesight of the astronomer who could discover them in the first place with an 8-inch telescope. Now that their existence is known, there should be no difficulty for anyone with a little practice and moderate eyesight in seeing the more conspicuous ones, with a telescope of ten or twelve inches aperture. Save under exceptional circumstances the power employed should not exceed one or two hundred.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be "morning star" during October, having just passed inferior conjunction. He will be at greatest elongation west from the sun on October 14, rising then about an hour and a half earlier than the sun. For a few days about that time it will be visible to the naked eye in the morning, near the east point of the horizon.

Venus is the brilliant "evening star" seen in the southwest after sunset. She will be at her greatest brilliancy October 29, but is rapidly approaching inferior conjunction so as to be visible but a short time in the evening. The diameter of Venus' disk increases from 28″, October 2, to 44.4″, November 2; while the phase decreases in the same time from 0.439 to 0.224. An interesting article on the planet Venus, by Professor G. V. Schiaparelli of the Milan Observatory, is contained in *L'Astronomie* for August, 1890. The writer discusses the observations of the elder Cassini and Bianchini, and concludes that there is no good ground for the assumption of $23^h\ 20^m$ as the rotation period of Venus. This period was not derived by the elder Cassini, but by his son, who himself could identify none of the markings which his father saw upon the planet. The period of about twenty-four days would much better satisfy the observations of Bianchini and equally well those of Cassini. Whether this period is one of rotation or of a large libration, like that of Mercury, cannot be decided from the data at hand.

Mars is still visible in the southwest in the evening, his course this month being eastward through the constellation Sagittarius. Very little has come to hand concerning physical observations of *Mars*, except the interesting article by Professor Pickering, which is given elsewhere in this journal.

Jupiter is in good position for observation in the early evening; but his low altitude in northern latitudes is unfavorable to the study of minute details of his surface. The great red spot, while not conspicuous, is more easily seen than during last year. It preserves the form of an oval ring and

its position relative to the great southern belt remains unchanged. An interesting paper on the belts and markings of Jupiter, by Mr. N. E. Green, is contained in the *Memoirs of the R. A. S.*, Vol. XLIX. It is the result of the study of a series of drawings of Jupiter, made by the writer during the period from 1859 to 1887. We quote some of the conclusions derived:

"It may be fairly concluded that Jupiter is surrounded with an atmosphere. That this atmosphere contains a large amount of vapor which is condensed, under varying circumstances, into forms greatly resembling those of terrestrial clouds. That from 60° to the poles this vapor forms quiescent and nearly unchanging caps of cloud. That this amount of condensation suggests the existence of extensive areas of water. That from 45° to the equator, both on the north and south, the planet is in a state of constant change, not only in its superficial markings, but also in the surfaces which underlie its atmosphere. That, notwithstanding this tendency to change, forms having considerable permanence are possible. That such forms are possible only in the direction of revolution, as is evidenced by the shape of the red spot, and the smaller spots following it in 1885, and therefore, all forms, whether of land or water, or intermediate states of matter, must agree with the direction of the belts. That although Jupiter may retain a large amount of original heat, it is not to any extent incandescent. This view is supported by the fact that the most frequent changes are confined to a space extending 45° on each side of the equator, or to that part most under the influence of the sun, indicating that the power producing these changes comes principally from without, and that the changes are chiefly of an atmospheric character. This remark does not apyly to the red spot, or to the copper color of the equator and belts, which in all probability were due to the action of forces within the body of the planet."

Saturn may be seen toward the east in the morning a couple of hours before sunrise. The angle of the earth below the plane of the rings is less than 5°, so that the details of the surface of the rings can be seen only with difficulty.

Uranus cannot be seen during this month. He will be in conjunction with the sun October 20. On April 13, 1890, two observers at Lick Observatory, with the 36-inch telescope, were satisfied that the planet Uranus had two faint bands on its surface. Their position angle was estimated at 90° ± by Professor Holden and 105° ± by Professor Schæberle. These results for position angle differ greatly from those obtained by Perrotin at Nice.

Neptune is visible all night after 8 P. M. He may be found with a telescope of 6 inches aperture about 1° north and 30′ east of the star Epsilon Tauri.

MERCURY.

Date.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Oct. 25.....	13 10.3	— 5 23	5 12 A. M.	10 54.2 A. M.	4 36 P. M.
Nov. 5.....	14 17.3	— 12 44	6 06 "	11 17.9 "	4 30 "
15.....	15 20.3	— 18 33	6 54 "	11 41.2 "	4 28 "

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			VENUS.		
Oct. 25	16 46.1	− 27 34	10 28 A. M.	2 29.3 P. M.	6 30 P. M.
Nov. 5	17 08.0	− 28 02	10 10 "	2 08.1 "	6 07 "
15	17 13.2	− 27 21	9 32 "	1 34.0 "	5 36 "
			MARS.		
Oct. 25	19 35.4	− 23 45	12 57 P. M.	5 18.4 P. M.	9 40 P. M.
Nov. 5	20 08.9	− 22 05	12 37 "	5 08.4 "	9 39 "
15	20 39.1	− 20 11	12 20 "	4 59.2 "	9 38 "
			JUPITER.		
Oct. 25	20 24.2	− 20 08	1 27 P. M.	6 06.9 P. M.	10 47 P. M.
Nov. 5	20 28.8	− 19 51	12 48 "	5 28.4 "	10 09 "
15	20 34.2	− 19 32	12 12 "	4 54.3 "	9 37 "
			SATURN.		
Oct. 25	11 02.9	+ 7 56	2 12 A. M.	8 47.3 A. M.	3 22 P. M.
Nov. 5	11 06.8	+ 7 35	1 34 "	8 07.8 "	2 41 "
15	11 09.7	+ 7 19	12 59 "	7 31.5 "	2 04 "
			URANUS.		
Oct. 25	13 42.5	− 10 03	6 03 A. M.	11 26.3 A. M.	4 50 P. M.
Nov. 5	13 45.1	− 10 18	5 23 "	10 45.7 "	4 08 "
15	13 47.4	− 10 31	4 47 "	10 08.6 "	3 30 "
			NEPTUNE.		
Oct. 25	4 18.7	+ 19 43	6 34 P. M.	2 00.1 A. M.	9 26 A. M.
Nov. 5	4 17.6	+ 19 41	5 50 "	1 15.7 "	8 42 "
15	4 16.5	+ 19 38	5 09 "	12 35.3 "	8 01 "
			THE SUN.		
Oct. 20	13 41.4	− 10 31	6 23 A. M.	11 44.8 A. M.	5 06 P. M.
25	14 00.4	− 12 16	6 30 "	11 44.1 "	4 58 "
30	14 19.8	− 13 57	6 37 "	11 43.7 "	4 51 "
Nov. 5	14 43.4	− 15 51	6 45 "	11 43.7 "	4 43 "
10	15 03.5	− 17 18	6 56 "	11 44.1 "	4 32 "
15	15 23.9	− 18 38	6 58 "	11 44.8 "	4 33 "
			THE MOON.		
Oct. 20	19 47.8	− 24 26	1 26 P. M.	5 50.2 P. M.	10 17 P. M.
25	0 40.1	− 0 49	4 19 "	10 22.1 "	4 34 A. M.
30	5 14.5	+ 23 27	6 43 "	2 36.1 A. M.	10 35 "
Nov. 4	9 45.5	+ 18 36	11 08 "	6 46.7 "	2 16 P. M.
10	13 40.0	− 6 08	4 26 A. M.	10 21.0 "	4 05 "
15	18 23.7	− 25 09	10 21 "	2 44.1 P. M.	7 05 "

Phases and Aspects of the Moon.

		Central Time. d	h	m	
First Quarter	1890	Oct. 21	1	36	A. M.
Full Moon	"	" 27	5	42	P. M.
Last Quarter	"	Nov. 4	10	13	A. M.
New Moon	"	" 12	7	38	"
Perigee	"	Oct. 24	4	00	"
Apogee	"	Nov. 5	3	12	"

Phenomena of Jupiter's Satellites.

d.	Central Time. h. m.					d.	Central Time. h. m.				
Aug. 26...	6 31	P.M.	I.	Sh.	Eg.	**Nov.** 2...	6 07	P. M.	I.	Sh.	In.
26	6 49	"	III.	Ec.	Re.	2	7 02	"	I.	Tr.	Eg.
30	7 37	"	II.	Sh.	In.	3	5 45	"	I.	Ec.	Re.
30	7 50	"	II.	Tr.	Eg.	9	6 09	"	III.	Oc.	Dis.
Nov. 2...	5 41	"	III.	Oc.	Re.	13	5 05	"	III.	Sh.	Eg.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T.	IMMERSION. Angle f'm N. P't.	EMERSION. Wash. Mean T.	EMERSION. Angle f'm N. P't.	Duration.
			h m	°	h m	°	h m
Oct. 14...	$\varkappa$ Virginis	4	6 09	21	Star 1.3′ N of moon's limb		
23...	τ^2 Aquarii	4	6 15	335	" 1.2′ " " "		"
31...	5 Geminorum	6½	11 46	95	12 59	237	1 13
Nov. 1...	52 "	6½	17 01	63	18 16	314	1 14

COMET NOTES.

Comet 1890, II. (Brooks, March 19.)—This comet will be in the same right ascension with the sun Oct. 11, but will then be 34° north of the sun, so that it will not set until about three hours after sunset. It is doubtful whether it can be seen in the twilight. The following ephemeris by Dr. Berberich is taken from *Astr. Nach. No. 2984.*

1890	α app.	δ app.	log r	log Δ	H
Oct. 4	13h 4m 56s	+ 28° 49.0	0.3872	0.5058	0.53
5	5 9	28 41.0			
6	5 23	28 33.2			
7	5 36	28 25.6			
8	5 50	28 18.2	0.3924	0.5086	0.51
9	6 3	28 11.0			
10	6 17	28 3.9			
11	6 30	27 57.0			
12	6 44	27 50.2	0.3976	0.5107	0.49
13	6 57	27 43.6			
14	7 10	27 37.2			
15	7 23	27 31.0			
16	7 36	27 25.0	0.4028	0.5123	0.48
17	7 49	27 19.2			
18	8 1	27 13.5			
19	8 14	27 8.0			
20	8 26	27 2.7	0.4080	0.5134	0.46
21	8 38	26 57.6			
22	8 50	26 52.6			
23	9 2	26 47.9			
24	9 13	26 43.4	0.4133	0.5138	0.45
25	9 24	26 39.1			
26	9 35	26 34.9			
27	9 45	26 30.8			
28	9 55	26 26.6	0.4185	0.5137	0.44
29	10 5	26 23.2			
30	10 14	26 19.6			
31	10 23	26 16.3			
Nov. 1	10 31	26 13.2	0.4237	0.5130	0.43
2	10 39	26 10.3			
3	10 46	26 7.7			
4	10 53	26 5.3			
5	13 11 0	+ 26 3.0	0.4288	0.5118	0.42

Comet 1890.....(Denning July 23.)—This comet is about three hours and a half east of the sun, and moving rapidly southward, through the constellation Scorpio. On Oct. 18, it will pass very near the bright star Antares. Its brightness is diminishing rapidly, so that it is doubtful whether it can

be seen with small telescopes. Mr. Wendell's ephemeris given below will enable the possessors of powerful telescopes to follow the comet for a short time at least.

Ephemeris of Comet C, 1890. (*Denning July 23.*)

Gr. M. T.		App. R. A.			App. Dec.		Log. *r.*	Log. *Δ.*
		h	m	s	°	′		
Oct.	1.5	16	5	32	− 11	9	0.1100	0.2051
	2.5		6	30	12	2		
	3.5		7	28	12	55		
	4.5		8	28	13	46		
	5.5		9	27	14	37	0.1121	0.2227
	6.5		10	27	15	26		
	7.5		11	26	16	14		
	8.5		12	27	17	2		
	9.5		13	28	17	48	0.1151	0.2398
	10.5		14	29	18	34		
	11.5		15	30	19	19		
	12.5		16	32	20	3		
	13.5		17	34	20	46	0.1190	0.2563
	14.5		18	36	21	28		
	15.5		19	39	22	10		
	16.5		20	42	22	51		
	17.5		21	46	23	31	0.1238	0 2720
	18.5		22	51	24	11		
	19.5		23	55	24	50		
	20.5		25	0	25	28		
	21.5		26	26	26	6	0.1293	0.2869
	22.5		27	12	26	42		
	23.5		28	19	27	19		
	24.5		29	26	27	55		
	25.5		30	34	28	30	0.1354	0.3009
	26.5		31	42	29	5		
	27.5		32	51	29	39		
	28.5		34	0	30	13		
	29.5		35	10	30	46	0.1422	0.3141
	30.5		36	20	31	19		
	31.5	16	37	30	−31	51		

O. C. WENDELL.

Harvard College Observatory, Sept. 20, 1890.

Solar prominences for July 1890. Number of observations, 12; number of prominences, 29; mean number of prominences, 2.416; highest prominence, 62″ (on the 31st).

DISTRIBUTION OF PROMINENCES.

Between	E. Limb.	W. Limb.	Between	E. Limb.	W. Limb.
0 and + 10°	0	0	0 and − 10°	0	3
+ 10 and + 20	1	0	− 10 and − 20	0	3
+ 20 and + 30	1	0	− 20 and − 30	1	4
+ 30 and + 40	0	0	− 30 and − 40	1	1
+ 40 and + 50	4	1	− 40 and − 50	3	0
+ 50 and + 60	0	3	− 50 and − 60	2	0
+ 60 and + 70	0	0	− 60 and − 70	0	0
+ 70 and + 80	0	0	− 70 and − 80	0	0
+ 80 and + 90	0	0	− 80 and − 90	0	0
				13	15

NOTE: During the month definition has been so poor here that I may have failed to see faint prominences. This would account for the small mean number.

E. E. REED, JR.

Camden Observatory, Aug. 1, 1890.

Smith Observatory Solar Observations. The following observations of the sun were made with the telescope except when otherwise specified. Those of June 12, 19, 23, 24, 25, 28 and on to August 16 were made by Charles E. Peet:

1890.	90° Mer. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
May 16	12 m.	0	0	0	Good.	Gran. good, both coarse and fine.
17	2:30 p m	2	4	1	Poor.	Fac.disturbance about spots near E. limb.
18	2:45 p m	1	1	0	Fair.	Gran fair at intervals.*
19	5 p m	2	4	0	Poor.	Seeing too poor to distinguish minute
20	11:45 a m	2	4	1	Fair.	Faint faculae on E. limb. [spots.*
21	5: p m	2	2	2	Very good.	Brilliant lines of faculae extending from S. group to limb.
23	4:30 p m	1	3	2	Fair.	Faint fac. like penumbra about two of the spots, nuc. minute and very black.
24	2 p m	0	0	1	Fair.	Gran. good.* Only a moment through a rift in the clouds.
26	9:45 a m	2	3	1	Fair.	Fac. near W. limb; fac. mottling all over disc. Gran. good.
27	11:30 a m	0	0	1	Fair.	One good group fac. near W limb.*
28	2 p m	0	0	1	Fair.	Gran. fair; faint fac. near E. limb.*
29	9:30 a m	0	0	0	Good.	No distinct fac. Gran. very good to limb.
30	4 p m	0	0	1	Good.	Gran. good; small gr. fac. quite near SW limb.*
31	4:45 p m	0	0	0	Fair.	Gran. fair. Fac. mottling near N. limb.
June 1	5 p m	0	0	0	Haze & clouds	Nothing visible. Too indistinct.
2	4:45 p m	0	0	0	Good.	Gran. very good to limb.
3	5 p m	0	0	0	Good.	Gran. good with power 221.
4	4:15 p m	1	4	1	Fair.	One group very bright fac. SE limb. Gran. good.
5	2:00 p m	1	10	1	Fair.	Gran. good. Spots mostly very minute.
6	4:30 p m	1	10	1	Good.	All but four spots very indistinct; faint fac. on W. limb.
7	4:30 p m	1	7	0	Bad.	Gran. poor; limb very unsteady.
8	3:15 p m	1	3	1	Poor.	Too near W. limb to count accurately.
10	3:30 p m	1	3	1	Fair.	Spots very faint surrounded by disturbed region.
11	4 p m	0	0	3	Poor.	Gran poor; fac. on W & SW limb.
12	1:45 p m	0	0	1	Fair.	Gran. fair; fac. near W limb.
15	4 p m	0	0	0	Poor.	Fac. mottling on E and W limbs.
16	4:30 p m	0	0	1	Good.	Gran. good. Continuous groups fac on W
19	2 p m	0	0	1	Fair.	Gran. surface fair. [limb.
21	5 p m	0	0	0	Fair.	Gran. quite good.
22	4 p m	0	0	2	Fair.	Faint fac. on NE and SE limb.
23	4 p m	0	0	0	Good.	Gran. good.
24	2 p m	0	0	0	Fair.	Gran. fair; glimpsed through clouds.
25	2 p m	0	0	0	Good.	Gran. good.
26	2:15 p m	0	0	0	Fair.	Gran. good.
27	4:45 p m	0	0	0	Rem'k'bly g'd	Gran. sharp and distinct.
28	5 p m	0	0	0	Good.	Gran. good.
29	3 p m	0	0	0	Poor.	Gran. fair.
30	2 p m	0	0	0	Poor.	Gran. difficult.
July 1	2 p m	0	0	0	Poor.	Gran. fair.
2	11 a m	0	0	0	Poor.	Gran. difficult.
3	4 p m	0	0	0	Fair.	
4	2 p m	11	7	1	Fair.	Spots surrounded by fac. region.
6	9 a m	1	9	1	Poor.	Spots surrounded by fac. region.
7	3:30 p m	1	40	1	Good.	Many of the spots counted are minute.
8	3:30 p m	1	11	0	Bad.	Seeing too poor to distinguish faint spots.
9	9 a m	1	27	1	Fair.	Fac. region about spots.
10	10 a m	1	23	1	Good.	Fac. region about spots.
11	9 a m	1	20	1	Poor.	Fac. about E group.
12	6:45 p m	1	3	0	Bad.	Seeing too poor to distinguish small spots.
13	3 p m	1	3	1	Poor.	Group of fac. near E. limb.
14	6:30 a m	1	2	2	Bad.	Gran. difficult.
15	9:15 a m	0	0	2	Fair.	Fac. on SW and NE limbs.
16	9:15 a m	0	0	3	Good.	
17	10 a m	1	1	0	Fair.	
18	8:15 a m	0	0	0	Good.	Gran. good.
19	3 p m	0	0	1	Bad.	
20	3 p m	0	0	0	Poor.	
21	10:45 a m	0	0	0	Fair.*	

* Projection on 20 cm. circle.

1890.	90° Mer. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
22	3 p m	1	2	0	Poor.	Penumbra about each spot.
23	1:30 p m	1	3	0	Fair.	Glimpsed through clouds.
25	11:15 a m	1	5	1	Fair.*	Fac. region about group.
26	7:30 a m	1	6	1	Fair.	Fac. region faint.
27	6:30 a m	1	8	1	Good.	Faint faculous region about spots.
28	3 p m	2	8	1	Poor.	Gran. good.
29	9 a m	3	5	3	Poor.	Gran. difficult.
30	4:45 p m	2	5	2	Good.	Gran. good.
31	5:45 a m	2	4	3	Fair.*	Gran. good.
Aug. 1	3 p m	2	7	3	Fair.	
2	12:30 p m	3	6	5	Fair.*	Bright fac. near S and NW limbs.
3	3 p m	1	1	3	Poor.	Faculæ faint.
4	3 p m	1	5	0	Bad.	Glimpsed through clouds.
5	10:30 a m	2	6	1	Bad.*	Gran. difficult.
6	2:45 p m	2	5	0	Good.*	
7	11:15 a m	2	3	2	Good.	
8	5:30 p m	2	4	1	Fair.	Spots in N W group very minute.
9	11:15 a m	0	0	1	Fair.	Fac. mottling on W and SW limbs.
10	4 p m	0	0	1	Fine.	
11	1:45 p m	0	0	0	Bad.	Gran. difficult.
13	5:45 p m	0	0	1	Bad.*	
14	6:15 a m	0	0	0	Bad.*	Gran. difficult.
15	8 a m	0	0	0	Good.	Gran. good.
17	6:15 p m	0	0	1	Fair.	
18	1:30 p m	0	0	0	Bad.	Seeing very bad; haze.
19	1:15 p m	0	0	1	Fair.	
20	3:15 p m	0	0	0	Fair.	Gran. fair.*
21	9:45 a m	0	0	0	Fair.	Gran. difficult.
22	2:30 p m	1	2	0	Fair.	Gran. fair. [visible.
23	3:45 p m	0	0	0	Bad.	Seeing very bad; hazy; no large spot
25	4:15 p m	1	6	1	Good.	Facular disturbance about group.
26	1:50 p m	1	19	1	Good.	Easternmost and westernmost spots have nuc. and penumbra.
27	1:30 p m	2	11	2	Poor.	11 large spots and many smaller ones, haze
28	9:30 a m	1	15	0	Fair.	2 spots with nuc. and penumbra.
29	3:15 p m	1	40	0	Fine.	Gran. good.
30	4 p m	1	41	0	Fine.	
31	4:35 p m	1	34	1	Good.	Fac. region about spots.
Sept. 1	2:20 p m	2	25	0	Bad.	4 spots in gr. 1 with nuc. and penumbra.*
2	2:15 p m	2	34	0	Fair.	Single glimpse through clouds. Unable to complete observation.*
4	11:10 a m	2	21	2	Fair.	Glimpsed through clouds. Fac. disturbance about each group.*
5	2:15 p m	2	12	1	Fair.	Glimpsed through clouds. Bright fac. reg. about group in N hemisphere.
6	12:45 p m	3	15	2	Fine.	2 spots in gr. 1 with nuc. and pen.*
7	5 p m	3	7	3	Bad.	Glimpsed at intervals through clouds.*
8	2:25 p m	3	9	2	Bad.	Haze.*
9	4:45 p m	2	4	0	Bad.	Haze too thick to distinguish well.*
10	2:35 p m	1	6	0	Bad.	Gran. difficult. Haze.*
11	1:10 p m	2	7	1	Fair.	Gran. difficult.
13	2:10 p m	0	0	0	Poor.	Gran. fair.
14	2:25 p m	0	0	0	Bad.	Gran. difficult.

* Projection on 20 cm. circle.

Four New Asteroids have been discovered since our last issue. No. 295 was discovered by Palisa at Vienna, Aug. 17.50 Gr. m. t.; R. A. $= 23^h\ 00^m\ 28^s$, Decl. $= -2°\ 24'$; daily motion -40^s and $-3'$. No. 296 was discovered by Charlois at Nice, Aug. 19. Its position Aug. 21.4749 Gr. m. t. was: R. A. $= 22^h\ 16^m\ 54.4^s$. Decl. $= -12°\ 20'\ 24''$; daily motion -13^s and $-6'$. Nos. 297 and 298 were discovered by Charlois at Nice, on the same night, Sept. 9. Their positions were: Sept. 9.3857 Gr. m. t.; R. A. $= 22^h\ 21^m\ 48.5^s$, Decl. $= -9°\ 02'\ 28''$ and Sept. 9.5364 Gr. m. t.; R. A. $= 0^h\ 38^m\ 32.9^s$, Decl. $= +2°\ 40'\ 04.''$ Daily motion of No. 297: -48^s and $-1'$; of 298 -56^s and $-1'$. No. 297 was of the 12th magnitude, the others of the 13th magnitude.

NEWS AND NOTES.

From what was said in our last issue, some have thought that the MESSENGER would be published hereafter every month in the year. This is a mistake, ten numbers will make an annual volume as heretofore.

On account of unexpected delays in securing photographs and suitable plates from engravers, we are unable to give frontispiece and biographical sketch this month, as was intended.

Since the article entitled stationary and long-enduring Meteor-Radiants by W. H. S. Monck, of Ireland, was in type, we have received a printed copy of the same matter in more extended form. Our vacation months have delayed the appearance of this paper and the later edition of it has already been published, as Mr. Monck informed us he intended to do some weeks ago.

A general list of observatories, astronomers, societies and astronomical journals has been prepared by A. Lancaster, Librarian of the Royal Observatory of Brussels. This third and last edition is a very useful reference book.

New Telescope for the University of Mississippi. In a recent letter from Professor R. B. Fulton, in charge of the department of Physics and Astronomy of the University of Mississippi we learn that a new telescope of considerable size will soon be ordered for the Observatory of that institution.

Portrait of Dr. Peters. Henry Harrison, of South Bergen, N. J., has just completed a life-sized portrait of the late Dr. Peters of the Observatory of Hamilton College, Clinton, N. Y. It is designed for the library of the college.

Polaris and Companion. We have had considerable correspondence lately concerning the appearance of the companion to Polaris. Amateur observers are requested to keep close watch of it, and to report anything unusual observed.

The New Equatorial Telescope for Carleton College Observatory. We have recent information from the makers of the rough discs for the new 16-inch equatorial for Carleton College Observatory, relating to progress of work on the same. Messrs. Shott & Gen, of Jena, have finished the flint disc, and it was shipped early last month. Mantois, of Paris, a few weeks ago had nearly completed the annealing of the crown disc. When these rough discs come into the hands of Professor Hastings of Yale University, and Mr. Brashear, of Allegheny, they will be thoroughly tested a second time before grinding begins. These well-known European makers of large optical discs seem already interested in the comparative merits of their work. It isnow believed that Carleton's new telescope will be in place about May 1, 1891.

J. E. Ingraham, President of the South Florida Railroad Company at Stanford, Florida, an interested subscriber to THE MESSENGER, has recently purchased a 4½-inch equatorial, and is planning to do regular observing with it.

Another Telescope for Chicago. We are interested to learn that Mr. George E. Hale of Chicago, Ill., is soon to have a new 12-inch equatorial especially adapted for spectroscopic work. Mr. Brashear is making the glasses and Warner & Swasey the mounting and dome. The dome is to be 26½ feet in diameter, and is the same size as the smaller one for the new Naval Observatory at Washington, D. C., the larger one being 45 feet in diameter. These three domes are now being made by Warner & Swasey, Cleveland, Ohio.

Perpetual Calendar. Some time ago we received from Professor R. W. McFarland a very neat form of a perpetual calendar. We will soon find a place for it in the MESSENGER.

Canals of Mars. We were so much interested in a private letter received in August from Professor W. H. Pickering, concerning the Canals of Mars, that we immediately asked him to give the benefit of his views to our readers. His important article is given in this issue.

Astromical and Physical Society of Toronto. Some years ago the Astronomical and Physical Society of Toronto was formed, but recently it has been incorporated and has adopted a Constitution and By-Laws, which has been printed in neat form and distributed as the first publication of the society. A circular setting forth its objects, and something of its plan of work is also received. Membership fees are $2 per annum. President, Charles Campbell, F. R. A. S., Director of the Toronto Observatory; Recording Secretary, D. J. Howell, 218 Becker Street, Toronto and Corresponding Secretary, G. E. Lumsden, Toronto. The new society is now in shape for work, and evidently means business.

A New Astronomical Society has been formed in England for the purpose of organizing and directing the energies of amateur observers in astronomical study. This movement is outside the province of the Royal Astronomical Society, whose fees and papers generally are beyond the ability of many who could work well in an organization differently constituted. The movement is a good one, and if rightly planned and directed must succeed.

Photographic Notes: The next meeting of the permanent committee on the photographic chart of the heavens will be held March 31, 1891.

In the Observatory for August, Mr. Common describes his instrument for measuring celestial photographs. It is in general plan like Mr. Robert's instrument for engraving from original negatives.

"The South American scientific party lately took some photographs of

the planet Mars. The pictures show the spots and markings on the planet very clearly. One of the negatives shows the Southern snow-cap distinctly larger than those taken the evening before."—*Photographic Times.*

The recent Lunar photographs of the Henry Brothers are exciting much interest. These are the pictures of the north and south horn of the moon, taken with the photographic telescope of the Paris Observatory. These pictures are enlarged to a scale of one metre to the diameter of the whole moon.

Knowledge for September contains parts of a photographic map of the normal solar spectrum made by Mr. George Higgs. These photographs are accompanied by an article by Mr. Ranyard on "Recent Advances in the Mapping of the Solar Spectrum." Mr. Ranyard's paper is full of suggestions as to the sensitizing of plates to different lights, kinds of instruments, their arrangement and method of use. As to Mr. Higgs' instrument, he makes the following statements: "The concave grating used by Mr. Higgs is mounted on one side of a circular table, ten feet two inches in diameter. The sensitive plate on which the normal spectrum is thrown is at the opposite extremity of the diameter of the circumference of the table, and the slit is also mounted on the circumference of the circle, in a position with respect to the grating and sensitive plate which varies according to the order of the spectrum, which is being photograph. The light of the sun it thrown by a heliostat upon the slit." The Henry Brothers have secured satisfactory photographs of stellar spectra.

Dr. H. C. Wilson has recently taken two excellent photographs of lightning. These pictures clearly show interesting details of the flash, and also bring out by lightning light, the foliage of trees within the range of the lens.

Stars having Peculiar Spectra. [Communicated by Edward C. Pickering, Director of Harvard College Observatory.] Photographs of stellar spectra taken at the Harvard College Observatory, and also at Mt. Harvard, near Chosica, in Peru, show a number of objects whose spectrum is peculiar in addition to those already published in THE SIDEREAL MESSENGER. Among them are the following stars:

No.	R. A. 1900.	Dec. 1900.	Magn.	Description.
A. G. C. 7179	$5^h\ 59.4^m$	$-\ 6°\ 42'$	5.8	F line bright.
" 15177	11 0.8	$-\ 65\ 1$	8½	Bright lines.
" 18859	13 47.7	$-\ 46\ 39$	6.6	F line bright.
" 19737	14 29.2	$-\ 41\ 43$	2.5	F line bright.
Z. C. 3612	17 55.1	$-\ 32\ 42$	9	Bright lines.
DM $-$ 19°4854	18 2.1	$-\ 19\ 25$	9.6	Bright lines.
DM $+$ 30°3639	19 31.9	$+\ 30\ 19$	9.3	Bright lines.
A. G. C. 29232	21 13.6	$-\ 45\ 27$	6.0	IV Type.

A. G. C. 19737 is η Centauri. As A. G. C. 18859, δ Centauri and μ Centauri are near, they form a group of stars in which the F line is bright. γ Cassiopeiæ, which has a similar spectrum is nearly 180° distant from this group. A. G. C. 15177, Z. C. 3612, and D. M. — 19° 4854 have a spectrum similar to that of the stars discovered by Rayet. The spectrum of DM + 30° 3639 differs from that of the other bright line spectra of which photographs have been obtained. A photograph of the spectrum of G. C.

2581 has also been taken. It seems to be peculiar, and is the same as that of G. C. 4628. In the *English Mechanic* Mr. D. Packer calls attention to two new variable stars, one preceding, the other following the cluster 5 M Libræ. Seventeen plates covering that region have been examined and measured here, and prove beyond doubt the variability of these two stars, the measures of the three comparison stars used differing by only .3, .3 and .6 respectively, while the measures of the variables show a variation of 1.9 and 2.9 magnitudes respectively. Three stars were found having a spectrum in which the lines due to hydrogen were bright. These stars were at once suspected of variability, which was confirmed on examination of the photographic charts previously taken. They are in the constellations Cælum, Scorpius, and Sagittarius, and have the following approximate places for 1900 R. A. 4^h 37.1^m, Dec. $-38°$ $33'$; R. A. 16^h 48.4^m, Dec. $-44°$ $57'$; and R. A. 20^h 11.1^m, Dec. $-39°$ $25'$. M. FLEMING.

Harvard College Observatory, Cambridge, Mass., Sept. 12, 1890.

Astronomy at the Indianapolis Meeting of the A. A. A. S. Section A. (Mathematics and Astronomy) of the A. A. A. S. was but slimly attended this year. As a result there were but few papers, but these were of considerable interest.

The address of Vice-President Chandler on the Variable Stars was a most elaborate aud painstaking review of the work done in this branch of Astronomy. Of the greatest value and interest was a classification of all the variables according to their periods. Professor Hough read a paper on Double Star Observations which was in the main a plea for the use of small telescopes for the measurements of wide and easy doubles. Professor Hough claimed that this work could well be done with telescopes of medium apertures and so the large glasses should be left free to devote all their time to work on close and difficult pairs.

On Friday, August 22d sections A. B. C. and D. were invited to hold their sessions at the Rose Polytechnic Institute at Terre Haute. At this meeting Professor Abbe read a paper by Frank H. Bigelow on a Study of Solar Corona. The paper was almost entirely mathematical and contained little of the physical side of the subject. It advanced an hypothesis however, in relation to the spots. If lines normal to tangents to the solar surface be dropped from the extremities of the coronal filiments they will, said Mr. Bigelow, fall within the Sun Spot Zones. From which fact he suggested that there might be a physical connection between the two phenomena. This was suggested as an hypothesis merely without any attempt at proof from observed data.

At the same meeting Mr. Brashear exhibited a negative of a portion of the Ultra Violet end of the spectrum and some photographs of the Moon by direct enlargement. These latter were made by the Henry Brothers and were magnificent specimens of lunar Photography.

At a subsequent meeting Mr. Charles H. Rockwell detailed to us some of his personal experiences on the Eclipse Expedition to Cayenne and exhibited one of the photographs taken there. Mr. Rockwell's time during the eclipse was occupied entirely in photographic work so that he was unable to observe any of the physical phenomena accompanying it.

For the next meeting, to be beld in Washington, the Association elected Professor Hyde of Cincinnati, Ohio, as Vice President and E. D. Preston of Washington, for Secretary. R.

On a New Variable Star near the Cluster 5 M Libræ. About 9^s or 10^s s. p. the cluster 5 M Libræ is a small star which (according to Dr. Copeland) D'Arrest records in his Leipzig observations as of the 11th magnitude. On April 22d, 1890, I estimated it 9.0 magnitude using for comparison the 9.5 star (Argelander) 18′ south of cluster. On May 14th it was 10th magnitude; May 21, 22, 23, 10.2 magnitude; June 6, 10.5; June 9, 19 also 10.5. On May 23 and June 9th I observed this object in Mr. Ingalls' 10-inch refractor. On the latter date it was equal to a star preceding on same parallel and fainter than the north component of a wide 10th magnitude pair just following the cluster. It is double, magnitudes 10 and 12 according to Mr. Espin May 28, lucida white. Subsequently I found an earlier observation with the above mentioned telescope, May 31, 1889 when I noted it as a bright unequal double star the lucida being the brightest of all stars surrounding the cluster.

On the nights, of April 22, May 9, 15 and June 9, Mr. Common obtained photographs of this cluster, two of which were exhibited at the June meeting of the R. A. S. I had the good fortune to be able to examine these plates and found a marked variation of brightness in this particular star and felt justified in calling attention to this object in a note to the Eng. Mech. for June 27, 1890.

Mr. Common has since examined all four plates and finds ample proof of variation. His values are April 22, 9.5; May 9, 11.0; May 15, 9.9; June 9, 10.5, being probably, a variable of some short period. My own telescope was a 4½-inch refractor (dialyte). D. PACKER.

London, July 11, 1890.

BOOK NOTICES.

Text Book of Mechanics, with Numerous Examples, by Thomas Wallace Wright, Professor in Union College. Messrs. D. Van Norstrand and Company, Publishers, 23 Murray and 27 Warren Street, 1890, pp 260, Price not given.

This is a new text book in Mechanics for use in the ordinary college curriculum where the Calculus is regularly taught in the course of pure mathematics. The use of the Calculus is the unusual feature in a book of this grade for the place it is intended to fill. But that the author is right in introducing this method of study for some of the themes of Mechanics there is no question. It is true that all students in the ordinary college courses were requested to know something of the mathematical instrument of investigation in most common and necessary uses in Mechanics, Physics and Astronomy. At the present time, without such knowledge, a student will not be able to follow much very elemental work in these branches that he would otherwise do easily and delightfully.

This book is divided into ten chapters with the following titles: Motion, force and motion, dynamics of a particle, statics of a rigid body, friction, work and energy, kinetics of a rigid body, elastic solids, statics of fluids, kinetics of fluids.

There are some very useful practical examples given in illustration of principles, such as those suggested by the Westinghouse air-break tests of 1887, and the new strong locomotive and other modern mechanisms that might be named. This book is commended to the attention of teachers. It will probably be introduced in Carleton College because the subject matter is good and because the students of all courses of study can use it, having previously pursued the elements of the Differential and the Integral Calculus.

An Introduction to Astronomy, designed as a Text Book for the use of students in College. New York: Charles Collins. The Baker & Taylor Company, Publishers, 740 Broadway. 1890 pp 236.

This volume is the third revision of the well-known work on astronomy commonly known as Olmsted's Introduction to Astronomy. It has a history deserving more space than we can now give to its notice. If memory serves us rightly, it was first published in 1844 by Professor Olmsted, who was then in charge of the department of Natural Philosophy and Astronomy of Yale College. In 1861 Julia M. Olmsted made the first revision. After several stereotype editions, in 1883 Professor Snell of Amherst College revised the work for the second time. During this year the third revision has been made by Professor Coffin, Ph. D. of LaFayette College. Considerable changes are made in the text, especially those relating to the work of the spectroscope, and some articles are entirely rewritten. Part of the tables are revised and enlarged. We notice that the parallax of 8.″848 is still retained. This value is undoubtedly too large, but there is yet no general agreement as to what numerical value shall take its place. This text-book is the faithful work of a line of excellent scholars for a half century.

Elliptic Functions. An Elementary Text Book for students in Mathematics. By Arthur L. Baker C. E., Ph. D., Professor of Mathematics in the Stevens School of the Stevens Institute of Technology, Hoboken, N. J. Messrs. John Wiley & Sons 53 East Tenth Street, New York City. pp. 118.

It is a source of gratification to us to know that Dr. Baker has recently given his attention to, and written a book much needed. We do not know of another in the English language that fills the place for which it is intended so well. It is true that the student will find abundant material for the study of Elliptic functions in the works of Abel, Euler, Jacobi and Legendre, but these writers are rather obscure and technical for the comfort of the average student, besides the further drawback of being written in a foreign language. In this book the author has taken the wise course of using such methods as are familiar to the ordinary student of the Calculus, and thereby necessarily omitting some parts of some themes to be found in other books. From the brief examination it does not appear however, that the usefulness of the text is impaired, but rather on the

whole, we think vastly improved. The chapters of the text have the following topics: Elliptic functions; periodicity of the functions; Landen's transformation; complete functions; evolution for φ; factorization of elliptic functions; the ϑ function; the ϑ and H functions; elliptic integrals of the second order; elliptic integrals of the third order; numerical calculations, q; numerical calculations, K; numerical calculations, u; numerical calculations, φ; numerical calculations, $E(k.\varphi)$; applications. We shall take pleasure in reading this book with our students in post-graduate studies in mathematics, as the theme is reached in our regular study.

A Handbook of Descriptive and Practical Astronomy, by George F. Chambers, III: The Starry Heavens, Fourth Edition. Oxford: At the Clarendon Press, 1890, pp. 337.

We are pleased to see the completion of the revision of this excellent Handbook of Astronomy. In our judgment Professor Chambers has done a work, in this direction, of unparalleled usefulness, and he will receive the hearty and deserved commendation of astronomers everywhere for it.

This part is presented in fourteen chapters accompanied by eighty-two illustrations, some of which are printed in colors.

The order of topics is as follows: Stars in general, Double stars, Variable stars, Clusters and Nebulæ, Variable Nebulæ, the Milky Way, the Constellations, Useful Catalogue of Naked-eye stars, On Finding the stars, a Catalogue of Celestial Objects, a Catalogue of Variable stars, a Catalogue of Red stars, a Catalogue of Binary stars, a Catalogue of New stars, index to part III. and general index to whole work.

We are agreeably surprised to notice that this part contains references to late work in so full a way. Recent progress in astronomy has been so great in many ways that a single volume, or even three of convenient size could not contain all that might be well and usefully said. We have space only to mention a few of these points, such as the comparison drawn by Mr. Monck of the results of stellar photometry by Pritchard and Pickering; generalizations from Struve's catalogue of double-stars and the conclusions drawn by Niesten. Chandler's generalization on the colors and periods of variable stars, historical statement relating to the aberration of Nebulæ and Clusters, the catalogue of the naked-eye star and the remarks accompanying it, in which we notice what is said on pages 120 and 121 regarding the work of Dr. Gould, entitled *Uranometria Argentina* and the *Harvard Photometry*, by Professor Pickering. While these works are distinctly and rightly commended, the author's criticisms on some features in each is severe, certainly to the limit of justice, and, we believe not intentionally beyond that point. It is not, we think, a piece of scolding which seems to be rather fashionable among some of our English writers now-a-days; and if it were, those two noble men most interested ought to be happy in view of the small charges against them.

It will be of some interest to the author to know that a considerable number of inquiries have been made at this office concerning the last edition of his work, and that some of the high schools of the leading cities of this country, at our suggestion, have purchased the entire work as reference books for the teachers and students in astronomy.

Elements of the Differential and Integral Calculus, Method of Rates by Arthur Sherburne Hardy, Ph. D., Professor of Mathematics in Dartmouth College. Boston, Mass., Messrs. Ginn & Co., publishers. 1890, pp. 239.

It is an interesting and significant sign of the times that the younger mathematicians and teachers in the branches of the so-called higher mathematics, feel called upon to write so many books on the elements of the calculus. The effect of this can but be good, and we are heartily glad to see it.

The first and most important new feature in this book is the elemental basis of its analysis. It is neither that of limits nor infinitesimals, but a method of rates. In his teaching the author has found that this method proves more satisfactory than any other for the first presentation of the object and scope of the Calculus. We say this is a new feature, or a new way of unfolding the elements of the science, and yet we do not forget the work done by Professor E. Loomis, of Yale College, a quarter of a century ago in this same direction, yet, of course not as complete and full as in this work. On the supposition of the change of rate of the variable function all the elementary rules are formed, and the troublesome question of orders of quantities is not raised, and fortunately, the student is given a start and some basis for independent thinking before he is required to form his opinions, or express them, on theoretical points which divide mathematicians as to best methods of presentation, if not in regard to the fundamental facts of the science. This point we like. It is the strong one in favor of the method of rates, and in our judgment gives it clearly the preference above all others.

The first part of this book is devoted to the Differential Calculus which covers 164 pages. The second part treats of the Integral Calculus. The range of the work is equal to that of the best books prepared for the courses of the modern college or scientific school. Its examples for practice are not as numerous as those of Bowser, but they are better graded than those of Olney. The arrangement of the matter on the page and the variety of type chosen are features that teachers will notice and commend, and they are equally aids to the student whether he knows it or not. We do not know of a book on the elements of the Calculus that impresses us more favorably on the first brief examination.

Books Received.

New Light from Old Eclipses, by Wm. W. Page, C. B. Barnes Publishing Co., St. Louis, Mo.

One Life, One Law, by Mrs. Myron Reed. Jno. W. Lovell & Company, Publishers, New York.

The Pathway of the Spirit, by John H. Dewey, M. D., Frank F. Lovell & Company, Publishers, New York.

Plane and Solid Geometry, by E. A. Bowser, L. L. D., D. Van Norstrand Company, Publishers, New York.

College Algebra, by Webster Wells, S. B., Messrs Leach, Sherwell & Sanborn, Publishers, Boston and New York.

Father Perry, The Jesuit Astronomer, by Aloysiaus L. Corlie, S. J., Published by the Catholic Truth Society, London.

Manual of Instruments for American Engineering and Surveying. Published by W. and L. E. Gurley, Troy, N. Y.